EVALUATION OF ENVIRONMENTAL INVESTMENTS PROCEDURES MANUAL

INTERIM: COST EFFECTIVENESS AND INCREMENTAL COST ANALYSES

by

Ridgley Robinson
William Hansen
Kenneth Orth

in collaboration with
Samuel Franco

U.S. Army Corps of Engineers
Water Resources Support Center
Institute for Water Resources
Alexandria, VA 22315-3868

U.S. Army Corps of Engineers
Waterways Experiment Station
Environmental Laboratory
Vicksburg, MS 39180-6199

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PREFACE

The work reported herein was conducted as part of the Evaluation of Environmental Investments Research Program (EEIRP). The EEIRP is sponsored by the Headquarters, U.S. Army Corps of Engineers (HQUSACE). It is jointly assigned to the U.S. Army Engineer Water Resources Support Center (WRSC), Institute for Water Resources (IWR) and the U.S. Army Engineer Waterways Experiment Station (WES), Environmental Laboratory (EL). Mr. William J. Hansen of the Institute for Water Resources is the Program Manager and Mr. H. Roger Hamilton is the Waterways Experiment Station Manager. Technical Monitors during this study were Mr. John W. Bellinger and Mr. K. Brad Fowler, of Headquarters, U.S. Army Corps of Engineers. The Field Review Group members that provide overall Program direction and their District or Division affiliation are: Mr. David Carney, New Orleans; Mr. Larry M. Kilgo, Lower Mississippi Valley; Mr. Richard Gorton, Omaha; Mr. Bruce D. Carlson, St. Paul; Mr. Glendon L. Coffee, Mobile; Ms. Susan E. Durden, Savannah; Mr. Scott Miner, San Francisco; Mr. Robert F. Scott, Fort Worth; Mr. Clifford J. Kidd, Baltimore; Mr. Edwin J. Woodruff, North Pacific; and Dr. Michael Passmore, Walla Walla.

This manual was prepared by Mr. Ridgley Robinson, Mr. William Hansen and Mr Kenneth Orth of the Technical Analysis and Research Division, IWR. The Automated Procedures accompanying this manual were developed by Mr. Samuel Franco and Mr. Daniel Brewer of the Resource Analysis Branch, Environmental Laboratory, WES. Previous IWR reports that contributed to this manual include: a draft Incremental Cost Analysis Primer for Environmental Resources Planning, prepared by Dr. Charlie Yoe of the Greeley-Polhemus Group, Inc; and Cost-Effectiveness Analysis for Environmental Planning: Nine EASY Steps, prepared by Mr. Kenneth Orth of IWR. In addition, the procedures described in this manual were field tested by the Planning Division of the St. Paul District. A special thanks goes to Mr. Bruce Carlson and Mr. Gary Palesh of St. Paul.

As indicated by the title, this is an *interim* edition of the manual. Subsequent revisions and improvements of both the manual and accompanying automated procedures will be made based on findings from future technology transfer workshops and field applications. Users of this manual are provided an opportunity to voice their comments by filling out a questionnaire found at the rear of the text.

The report was prepared under the general supervision at IWR of Mr. Michael R. Krouse, Chief, TARD; and Mr. Kyle E. Schilling, Director, IWR; and at EL of Mr. H. Roger Hamilton, Chief, RAB; Dr. Robert M. Engler, Chief, Natural Resources Division; and Dr. John W. Keeley, Director, EL.

At the time of preparation of this report Mr. Kenneth H. Murdock was Director, WRSC and Dr. Robert W. Whalin was Director of WES. Commander of WES was COL Bruce K. Howard, EN.

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EXHIBITS

ABBREVIATIONS

B-C ratio	ratio of benefits to costs
C-B ratio	ratio of costs to benefits
EC	engineering circular
EEIRP	Evaluation of Environmental Investments Research Program
ER	engineering regulation
HEP	Habitat Evaluation Procedures
HU	habitat unit
IWR	Institute for Water Resources
NED	National Economic Development
OMRR&R	operation, maintenance, repair, replacement and rehabilitation
P&G	Principles and Guidelines
U.S.	United States
USWRC	United States Water Resources Council
WES	Waterways Experiment Station

CHAPTER 1
OVERVIEW

"Efficiency is the extent to which an alternative plan is the most cost effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment."
(Principles and Guidelines; U.S. Water Resources Council; 1983)

INTRODUCTION

Since the early 1970's, the emphasis of the Corps' water resources program has shifted from the construction of new projects to the improved operation or modification of existing projects with increased concern for the environment. Environmental restoration is now a "priority" mission in the Corps' budgetary process, along with the more traditional missions of navigation and flood control. The new emphasis on projects to provide environmental restoration benefits offers opportunities for Corps' environmental scientists to broaden their traditional role in project planning. This traditional role has typically involved assessment of the environmental impacts of water development projects and planning for the mitigation of those impacts. Now, our environmental scientists have the opportunity to participate in more proactive planning to accomplish environmental restoration objectives.

This is not to imply that planning projects to provide environmental benefits is the sole responsibility of environmental staff elements. Rather, as with planning for other purposes, environmental restoration or mitigation planning requires an interdisciplinary team approach. While economists may be most comfortable with the rationale for, and mechanics of, cost effectiveness and incremental cost analyses, the analyses require input from a variety of disciplines. For example, environmental scientists will typically determine the environmental variables to be analyzed and the methods by which changes in those variables will be measured and communicated as *environmental outputs*. Staff from engineering, environmental, and other elements will identify alternative plans to affect changes in those variables. Similarly, economists, cost engineers, real estate specialists and others must combine their expertise to estimate the *economic costs* of those alternative plans. It is important that all members of a study team, regardless of their discipline, have an understanding of how their respective inputs must come together to facilitate plan formulation and evaluation.

Currently, environmental plan evaluation within the Corps consists of a comparison of the environmental outputs and the economic costs of alternative plans. Costs for environmental restoration or mitigation projects include essentially the same types of financial costs that are incurred in projects for flood damage reduction, navigation and other purposes; including costs for preconstruction engineering and design, real estate, construction, and ongoing operation, maintenance and rehabilitation. Yet, unlike planning for traditional economic development projects, there is no currently accepted method for quantifying environmental benefits (environmental "outputs"), in monetary terms. Without a monetary measure of project benefits, it's not possible to conduct a traditional benefit-cost analysis for the evaluation of project alternatives. However, short of benefit-cost analysis, economics can provide other tools to assist in plan evaluation.

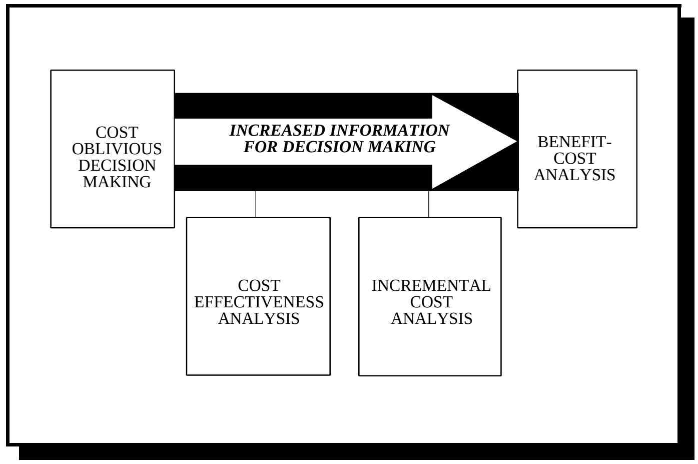


Figure 1-1 Decision-Support Continuum

Figure 1-1 shows some tools of economic analysis that can be used to provide varying levels of information to support decision making. This decision-support continuum ranges from cost oblivious decision making (ignore all information about costs) to benefit-cost analysis (a mathematical comparison of benefits and costs). Between these two extremes, the economic tools of cost effectiveness analysis and incremental cost analysis can provide information to support decision making (Yoe 1992).

Benefit-cost analysis is generally considered the "*best case scenario*" for Federal water resources plan evaluation. In benefit-cost analysis, the monetary cost of a plan is subtracted from the monetary value of the benefits to be provided by that plan to compute net benefits. When there is a range of alternative plans, the plan that provides the most net benefits is typically the recommended plan. When project benefits aren't measured in dollars, cost effectiveness and incremental cost analyses offer "*next-best*" approaches for plan evaluation. While the cost effectiveness and incremental cost analyses of alternative plans may not identify a unique or "optimal" solution, they can lead to better-informed choices from among alternatives by elevating the decision making process above cost oblivious decision making (Yoe, 1992). The tools of cost effectiveness analysis and incremental cost analysis weigh the costs of restoration and mitigation plans with their nonmonetary measures of output. Such evaluation is at the heart of the analyses and is the basis for their application in environmental planning.

The cost effectiveness analysis and incremental cost analysis procedures offered in this manual provide planners with a structured, yet flexible, framework to assist in environmental plan evaluation. Cost effectiveness analysis can assist in the formulation of cost effective alternative plans. Cost effectiveness analysis can also be used to screen out plans that are not cost effective from further consideration. Incremental cost analysis reveals changes in costs as levels of environmental outputs increase. In the absence of a common measurement unit for comparing the non-monetary benefits with the monetary costs of environmental plans, cost effectiveness and incremental cost analyses are valuable tools to assist in decision making.

Proper use of cost effectiveness and incremental cost analyses can help decision makers allocate limited resources more efficiently and avoid the selection of economically irrational plans and projects. The results of these analyses, displayed as graphs of outputs against costs, permit decision makers to progressively compare alternative levels of environmental outputs and ask if the next level is "worth it"; that is, is the additional environmental output in the next attainable level worth its additional monetary cost? Examples of "typical" cost effectiveness and incremental cost curves are included in Figure 1-2.

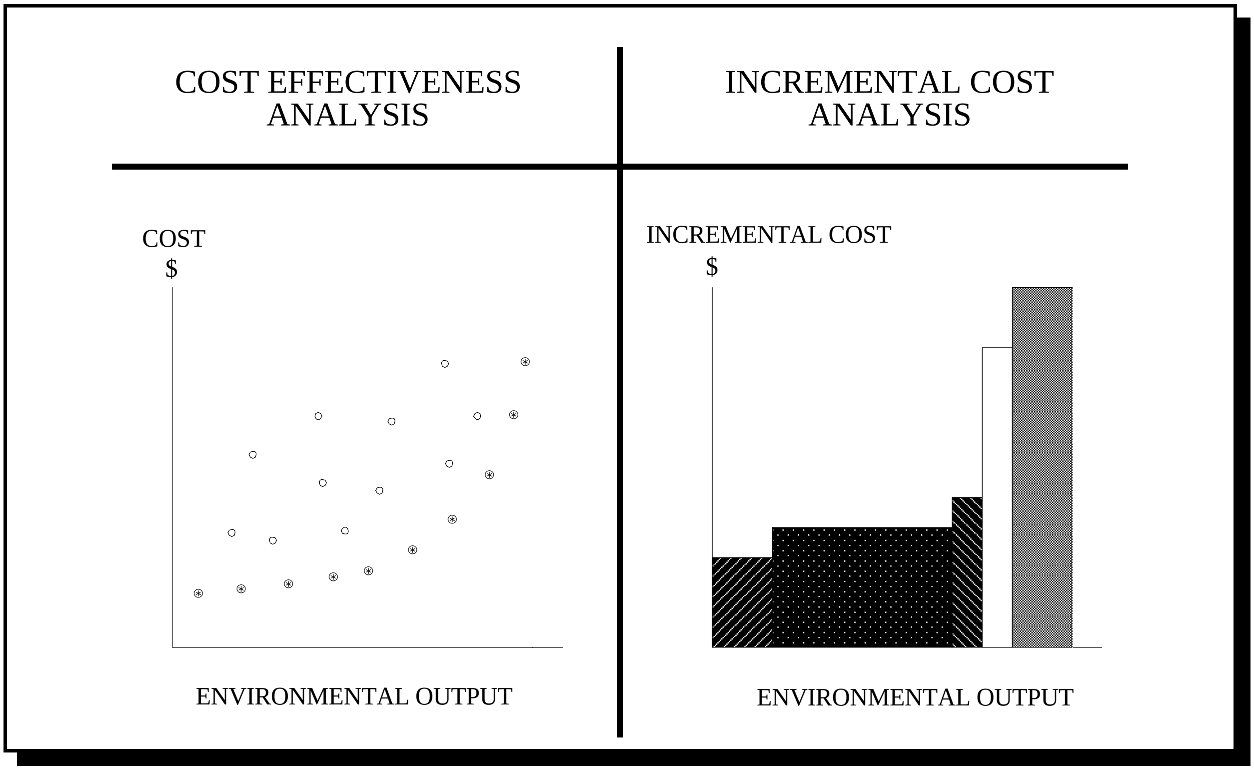


Figure 1-2 Cost Effectiveness and Incremental Cost Analyses

PURPOSE, AUDIENCE & SCOPE

PURPOSE

The purpose of this manual is to serve as a guide for conducting cost effectiveness analysis and incremental cost analysis for the evaluation of alternative environmental restoration and mitigation plans. This document will present a procedural framework for conducting the cost analyses, and discuss how they fit into and contribute to the Corps' planning framework. The manual will also present techniques to assist in the formulation of environmental restoration and mitigation plans. The procedures included in this manual are based upon the conceptual framework of the U.S. Water Resources Council's Principles and Guidelines and comply with current Corps' regulations and guidance on incremental cost analysis for planning studies of the restoration or mitigation of environmental resources.

In addition to discussing the conceptual underpinnings, practical procedures, and implications for decision making of cost effectiveness and incremental cost analyses, the manual will also provide instruction in the use of automated computational procedures for conducting the analyses. These automated procedures will execute the otherwise time-consuming exercise of "number-crunching", and should free planners to examine and evaluate alternative plans and their respective costs and outputs. The ultimate goal of this manual is to result in more informed decision making in the evaluation of alternative environmental restoration and mitigation plans.

AUDIENCE & SCOPE

The primary audience of this manual are those with the principal responsibility for formulating and evaluating environmental plans. As there is no one discipline with this responsibility, the manual is intended to provide readers from a variety of backgrounds with an understanding of cost effectiveness and incremental cost analyses in environmental restoration and mitigation planning. The intended audience is not limited to Corps' staff elements. Environmental restoration and mitigation planning studies will typically involve parties outside the Corps. This manual may provide an understanding of the rationale for, and mechanics of, cost effectiveness and incremental cost analyses in plan evaluation to interested representatives of other groups and agencies as well as local cost sharing partners.

The procedures presented in this manual are typically for use in planning studies of projects to provide environmental restoration or mitigation benefits, although they could be adapted to a variety of decision making levels and situations. To simplify discussion, the manual will often refer to such studies as "environmental restoration studies"; however, all concepts and procedures presented are equally applicable to mitigation studies.

This *interim* manual is a preliminary effort to provide environmental plan formulation and evaluation tools to practitioners in the field. We have identified several areas to receive more attention in the next *final* version of this manual. For example, we plan to add: an appendix addressing cost discounting; a section addressing, (in more detail), the treatment of different or incommensurable output measures in a single study; the treatment of non-additive cost and output estimates of different management measures; and the treatment of uncertainty in the reliability of cost and output estimates. We may also include, as an additional appendix, a case study of the application of the analyses to a planning study which involves many of these types of complex issues, similar to the Bussey Lake Demonstration Study Report (Carlson, 1993).

We welcome any comments regarding the concepts and procedures presented in this manual, as well as additional issues which you feel should be addressed. All such comments received will be considered for incorporation in the final version of this manual. To facilitate the exchange of user comments, we have enclosed a questionnaire at the rear of this document. The authors appreciate the return of completed questionnaires, which will provide us with needed information to assure that the final version of the manual is responsive to user needs and concerns.

BACKGROUND

A series of regulations and guidance has evolved requiring the use of economic analyses in environmental planning. In 1983, the U.S. Water Resources Council published the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G). This guidance is intended to ensure that proper and consistent plans are developed by Federal agencies to "enhance their ability to identify and recommend to the Congress economically and environmentally sound water project alternatives". The P&G requires that:

> "In general, in the formulation of alternative plans, an effort is made to include only increments that provide net National Economic Development (NED) benefits after accounting for appropriate mitigation costs. Increments that do not provide net NED benefits may be included, except in the NED plan, if they are cost effective measures for addressing specific concerns." (paragraph 1.6.2 (b))

While the P&G places emphasis on plans to achieve NED benefits, it does leave the door open for *cost effective* plans to achieve other benefits, such as environmental benefits.

Corps of Engineers guidance requires an incremental cost analysis for recommended environmental restoration and mitigation plans. The Corps of Engineers planning regulation number 1105-2-100, Guidance for Conducting Civil Works Planning Studies (U.S. Army Corps of Engineers, 1990) requires:

> "An incremental cost analysis shall be performed for all recommended mitigation plans. The purpose of incremental cost analysis is to discover and display variation in costs, and to identify and describe the least cost plan."

The requirement of incremental cost analysis for the mitigation of adverse project impacts was extended to the *restoration* of fish and wildlife resources through Policy Guidance Letter #24, (U.S. Army Corps of Engineers, 1991).

The Corps' recent engineering circular 1105-2-210, Ecosystem Restoration in the Civil Works Program underscores the importance of cost effectiveness and incremental analysis in ecosystem restoration planning. The circular states:

> "Cost effectiveness analysis and incremental cost analysis are fundamental concepts in project formulation and evaluation. These analyses provide ways of thinking about outputs resulting from the various levels of expenditures. Ecosystem restoration studies differ from traditional studies only in that not all benefits are monetized."
>
> "A cost effectiveness analysis is conducted to ensure that least cost alternatives are identified for various levels of environmental output. After the cost effectiveness of the alternatives has been established, subsequent incremental cost analysis is conducted to reveal and evaluate changes in cost for increasing levels of environmental output."

> "Although incremental cost analysis does not provide a discrete decision criterion (such as the maximizing of net benefits in NED analysis), it provides for the explicit comparison of the relevant changes in costs and outputs on which such decisions should be made."

All the above guidelines and regulations collectively require that project planning for the restoration or mitigation of environmental resources include an analysis of the economic efficiency of alternative plans and plan components. The cost effectiveness analysis and incremental cost analysis procedures in this manual provide a framework for meeting this requirement. The analyses are tools that can help to assure that environmental outputs are produced efficiently.

In a 1989 survey of Corps planning staff titled, *"Effectiveness of Incremental Analysis for Mitigation Planning"*, many respondents reported that incremental cost analysis was perceived as a hindrance to plan formulation and selection. The most common criticisms pointed to the analyses' time-intensive nature and to a lack of clear procedural guidance on their implementation (Reese, 1989). To address these criticisms, Corps Headquarters tasked the Institute for Water Resources to better define how cost effectiveness and incremental cost analyses could be accomplished. This resulted in an overview, titled *Economic and Environmental Considerations for Incremental Cost Analysis in Mitigation Planning* (Greeley-Polhemus Group, 1991), and a draft manual titled *Incremental Cost Analysis Primer for Environmental Resources Planning* (Yoe, 1992). These studies provided background research that evolved into *Cost Effectiveness Analysis for Environmental Planning: Nine EASY Steps* (Orth, 1994). Concurrent with this work, IWR supported a field demonstration to test the applicability of the *Nine EASY Steps* procedures. The resultant report, *Bussey Lake: Demonstration Study of Incremental Cost Analysis in Environmental Planning* (Carlson, 1993), was completed by the Corps' Saint Paul District in December 1993.

This manual builds upon all of the above research with the intent of providing a comprehensive procedures manual for cost effectiveness analysis and incremental cost analysis that consolidates the work and experiences to date. The manual also adds to this work with the introduction of automated procedures developed to reduce the study time required of field planners. An understanding of the concepts and procedures in this manual will assist Corps planners in conducting proper and complete environmental restoration and mitigation planning studies.

ORGANIZATION OF THE MANUAL

The manual consists of three chapters and an appendix. This chapter, **Chapter One**, describes the purpose, scope and audience, background, and organization for the manual. **Chapter Two** outlines the role of cost effectiveness and incremental cost analyses in environmental planning. The chapter will provide discussion of basic economic concepts upon which cost effectiveness and incremental cost analyses are based and how an understanding of those economic concepts and the cost analyses can contribute to environmental plan formulation and evaluation. The chapter also includes an example application of cost effectiveness and incremental cost analyses. **Chapter Three** provides a framework for both environmental plan formulation and environmental plan evaluation. The chapter presents step-by-step procedures for formulating plans and then evaluating those plans through cost effectiveness analysis and incremental cost analysis. The chapter will shed light on some of the more difficult conceptual issues of the cost analyses, discuss the required inputs to the analyses, provide "how-to" steps for conducting the analyses, and then discuss how the outputs of the analyses are interpreted and used to support decision making. The **Appendix** contains instructions for the use of the automated computational procedures to do most of the "number-crunching" necessary to conduct cost effectiveness and incremental cost analyses.

CHAPTER 2
A ROLE FOR ECONOMICS IN ENVIRONMENTAL PLANNING

"Because policy choices about resources and environmental quality are made in a political context and are likely to involve comparisons and trade-offs among variables for which there is no agreement about commensurate values, monetary benefit-cost analysis is not a simple decision rule. [Economics] is simply a tool for organizing and expressing certain kinds of information on the range of alternative courses of action."
(A. Myrick Freeman III; The Measurement of Environmental and Resource Values - Theory and Methods; Resources for the Future, 1993.)

INTRODUCTION

There is a long-lived debate about the appropriateness of using economics in the evaluation of environmental resources. This debate is steeped in such issues as the appropriateness of placing dollar values on the existence of specific species. Cost effectiveness and incremental cost analyses are not directly concerned with such controversial issues. The cost analyses themselves do not make any value judgments, but rather they provide information to facilitate such judgments by decision makers and other stakeholders.

The cost analyses presented in this manual will usually not lead, and are not intended to lead, to a single best solution as is the case in benefit-cost analysis. They can, however, improve the quality of decision making by ensuring that a rational, supportable, focused and traceable approach is used for considering and selecting from among alternative plans for producing environmental outputs. The objective of this chapter is to provide the reader with an introductory understanding of the economic concepts upon which the tools of cost effectiveness and incremental cost analyses are based, and the relevance of those concepts and tools to environmental restoration planning.

Although cost effectiveness and incremental cost analyses are tools of economics, an understanding of their usefulness does not require extensive knowledge of economic theory. Rather, an introduction to a handful of economic concepts and terms should facilitate an understanding of how the cost analyses are conducted and what they can contribute to environmental planning. For a more comprehensive discussion of how economic concepts relate to the evaluation of water resources projects, you may wish to read the *Overview Manual for Conducting National Economic Development Analysis*, IWR Report 91-R-11, (Greeley Polhemus Group 1991). The first task in this chapter is to identify those economic concepts which have implications for environmental planning; and more specifically, for cost effectiveness and incremental cost analyses.

ECONOMIC CONCEPTS FOR ENVIRONMENTAL PLANNING

Economics has traditionally been divided into two fields: macroeconomics and microeconomics. Supply and demand analyses provide the basic organizing framework for the study of each field. Where macroeconomics concentrates on the behavior of entire economies, microeconomics focuses on individual decision making units. Environmental restoration project planning is microeconomic in nature. It is concerned with decision making at the site level; decisions like: "How many habitat units should we restore at site *X*?"; or "What is the least expensive way of producing *Y* habitat units at site *X*?" Cost effectiveness and incremental cost analyses can provide useful information for supporting decisions of this type. Such choices need to be made because of the scarcity of resources.

SCARCITY AND CHOICE

The concept of *scarcity* is a potential source of confusion in environmental restoration planning. This is because economists and environmentalists often have different perspectives on the concept's meaning. The environmentalist' view of scarcity typically embodies some idea of relative abundance. For example, an environmentalist might see a particular species as scarce because it is relatively less abundant than at some prior point in time. The importance that society places on the "relative scarcity" of particular species can be witnessed by the passing of such national preservation laws as the Endangered Species Act.

An economist sees the concept of scarcity in a slightly different light. To an economist, a resource does not have to be "hard to come by" to be considered scarce. The only requirement for "economic scarcity" is that there be more than one use for a resource. For example, a riverbank can support a levee, provide habitat for wildlife, or be used as a boat launch. The riverbank is economically scarce in the sense that *it can be used* to produce different outcomes. The riverbank can be thought of as an input, that through various different types of manipulation, can be transformed into different types of outputs. Economics is concerned with assuring that inputs are being used such that they produce the highest-valued of possible outputs - regardless of whether the value of those possible outputs can be described and traded off in dollars.

Neither meaning of scarcity is incorrect and both can play important, although different, roles in environmental restoration planning. The idea of "relative scarcity" can go a long way in arguing the significance of an environmental resource under study - especially if the resource has been designated as *threatened* or *endangered* by the Secretary of the Interior under the authority of the Endangered Species Act. Information about a resource's relative scarcity can help to subjectively describe the non-monetary value of that resource. Such information, along with the results of cost effectiveness and incremental cost analyses, is useful for providing decision makers with the information they need to select plans. Of special interest to the cost analyses is the concept of "economic scarcity" and its implications.

The pervasiveness of "economic scarcity" means we cannot have, or do, everything we want. We can, however, have, or do, some of the things we want. Scarcity forces us to make choices from among the options available to us. Every choice we make costs us the opportunity to have, or to do, something else. When we have the opportunity to do more than one thing with a resource - for example, to use a riverbank as wildlife habitat or to support a levee - the choice we make costs us an opportunity to have done something else. These foregone opportunities are what economists call *opportunity costs*.

Suppose that to restore fish and wildlife habitat downstream from an existing reservoir, we want to increase downstream flows by drawing down the reservoir's water level. Assume that the only management action required is to open a spill gate and therefore there are no implementation costs. For this action to be economically rational, the value of the environmental outputs accruing from the increased downstream flows must outweigh the opportunity cost of the highest valued combination of other outputs foregone (for example, water supply, hydropower, recreation, and even environmental outputs that were being, or could have been, provided by the higher reservoir water level). If the value of the environmental outputs cannot be quantified in dollar terms, this judgment will be inherently subjective. Still, for this subjective judgment to be well-informed (that is, based upon knowledge of all foreseeable implications of the decision), it is important that the opportunity costs of foregone benefits be accounted for and brought to the table in the decision process.

SUPPLY AND DEMAND

Resource valuation is concerned with determining the *demand* for an output; that is, the value of the output, or "what it's worth". The value of environmental resources is at the root of much of the controversy over the use of economic principles in environmental planning. As previously mentioned, the value of many benefits provided by environmental projects cannot be readily quantified in monetary terms. As a result, demand-side, environmental resource value judgments are often left to decision makers who must decide if successive levels of environmental outputs are worth their respective total costs. Cost effectiveness and incremental cost analyses provide organized information to support such decisions; information describing the costs of *supplying* different output levels.

It is relatively straightforward to estimate the costs of supplying environmental restoration or mitigation. The *supply* of project outputs is tied to *production* processes and their associated costs. Cost effectiveness analysis and incremental cost analysis are concerned with the production of environmental outputs. Specifically, cost effectiveness analysis is concerned with evaluating the efficiency of alternative means of producing environmental outputs; incremental cost analysis is concerned with identifying and displaying variations in cost for the production of different output levels.

PRODUCTION

Production involves combining a set of one or more *inputs* together via some prescribed *technology* in order to arrive at desired *outputs*. Economic production theory fits well within the context of environmental planning. Alternative environmental restoration plans can be thought of as alternative production processes. By combining inputs (environmental resources, labor, capital, and equipment), we can produce environmental outputs by transforming a future without-project condition to a future with-project condition. Each alternative plan utilizes a different technology, or technique, for producing those outputs. Some techniques cost more than others; and similarly, some produce more output than others.

In some cases, it may be informative to examine the relationship of *production efficiencies* across a range of plans. A plan's relative production efficiency can be evaluated by comparing its *cost per unit of output* to the those of other plans. The plan which produces output at the lowest cost per unit can be thought of as the most efficient method of production. Such information can be useful, for example, when comparing different plans which produce the same output level: a component of cost effectiveness analysis. While production efficiency information can be useful in conducting cost effectiveness analysis, it can be misleading, and in many cases should not be used for, plan selection decisions. Selecting a plan based only upon its production cost overlooks the important question of “is its level of output worth its cost?”. Rather, incremental cost and output information should be used to support plan selection decisions.

Environmental Output Estimation Models as Production Functions

Some environmental models, such as those developed for the U.S. Fish and Wildlife Service’s Habitat Evaluation Procedures, or HEP, are designed to model specific natural production processes. The economist would think of such models as *production functions*. A production function describes the relationship between inputs and outputs such that a change in inputs can be translated into an expected change in outputs. Environmental “production function” models, like the HEP models, can be useful in quantifying the environmental outputs produced by specific management measures.

Take, for example, the HEP model for *riverine yellow perch* (Krieger 1983). This model describes the *habitat variables* which provide the life requisites for riverine yellow perch. The habitat variables in this model include: percentage of pool and backwater area; percentage of cover in pool and backwater areas; temperature; dissolved oxygen; and pH. Through a formula, the model converts site specific values for these habitat variables into a quantified measure of environmental output called *habitat units*. The effect of a proposed management measure (an input) on each habitat variable can be estimated and the corresponding values can be converted into a “with-management measure” number of habitat units (output). In this case, the difference between future habitat units without the management measure and future habitat units with the management measure equals the habitat units produced by the measure.

The purpose of cost effectiveness and incremental cost analyses in environmental planning is to promote the efficient production of environmental outputs. We don't want to pay more than is necessary for the production of restoration outputs. Production is inefficient if a given level of output is produced at a higher cost than is necessary, or if more output could have been produced with the same or fewer resources. Of ultimate interest in cost effectiveness and incremental cost analyses are the costs associated with the different output levels produced by different measures or plans.

COSTS

Cost is a sacrifice that must be made in order to do or acquire something. Cost analysis plays a central role in virtually every management decision, including decision making in environmental planning. In environmental planning, we examine the *cost* of plans and the output provided by those plans to determine their relative production efficiency. Also, we examine how *cost* varies as output levels increase to facilitate the selection of a desirable scale of output.

If you remember the decision-support continuum of Figure 1-1, basing decisions upon cost information will lead to more informed and supportable decisions than will cost oblivious decision making. Cost-oblivious decisions argue “we will produce this level of output no matter what it costs”. Within the institutional and budgetary constraints of the Corps, cost oblivious decisions are typically not supportable. Cost analysis will lead to more supportable environmental plans and projects.

Environmental Project Cost Components

For the purposes of this manual, we will talk about two main components of cost for environmental projects: *implementation costs*, and *opportunity costs of foregone NED benefits*. A discussion of an additional issue with possible implications on the calculation of project costs, *incidental NED benefits*, can be found in Chapter Three.

Implementation Costs are what economists might refer to as “explicit costs”; they are the out-of-pocket, cash outlays for the production of environmental outputs. Examples of implementation costs might include outlays for preconstruction engineering and design, real estate, construction, OMRR&R (operation, maintenance, repair, replacement and rehabilitation), and monitoring.

Opportunity Costs of Foregone NED Benefits are what economists might refer to as “implicit costs”; they don't cost us money we already have “in pocket”, but rather they cost us the opportunity to have done something else (that is, to have produced other NED benefits). The P&G specifies the following goods and services as NED benefits:

(1) Municipal and Industrial Water Supply;
(2) Agricultural Floodwater, Erosion and Sedimentation Reduction;
(3) Agricultural Drainage;
(4) Agricultural Irrigation;
(5) Urban Flood Damage Reduction;
(6) Hydropower;
(7) Inland Navigation;
(8) Deep Draft Navigation;
(9) Recreation;
(10) Commercial Fishing; and
(11) Other Categories of Benefits.

See the P&G for a discussion of procedures for estimating these NED benefits. Additional Corps’ guidance for estimating these benefits can be found in IWR's *National Economic Development Procedures Manual* Series.

Total Cost

For the purposes of cost effectiveness and incremental cost analyses, the total cost of an environmental restoration or mitigation plan equals the sum of all implementation costs and opportunity costs of foregone NED benefits. The total cost of each alternative plan under study, together with its associated level of output, can be used as the inputs to cost effectiveness analysis to identify all cost effective production alternatives (plans).

Again, a discussion of an additional issue with possible implications on the calculation of total costs, *incidental NED benefits*, can be found in Chapter Three.

Average Cost

Average cost is calculated by dividing total cost by total output. The average cost for a particular level of output is the *cost per unit* for that level. If an alternative provides 100 units of output at a total cost of $1000, the average cost is $10 per unit for that alternative. Average costs can facilitate the comparison of production efficiencies across alternatives by placing each alternative plan in a common metric: dollars per unit of output.

Incremental Cost

Incremental cost is the change in cost that results from a decision. It is for this reason that incremental cost is the most important cost concept for most production decisions. In the context of environmental planning, incremental cost is the additional cost incurred by choosing to select one plan instead of another plan. Incremental cost is computed by subtracting the cost of the last alternative under consideration from the cost of the alternative currently under consideration. It's the difference in cost between one alternative and the next . For example, if Alternative A costs $1000 and Alternative B costs $1,750, then the incremental cost of deciding to implement Alternative B instead of Alternative A is $1,750-$1,000, or $750. This incremental cost information simply tells us that Alternative B is $750 more costly than Alternative A.

TOTAL COST AND TOTAL OUTPUT IN COST EFFECTIVENESS ANALYSIS

In cost effectiveness analysis, we want to filter out plans that produce the same output level as another plan, but cost more; or cost either the same amount or more than another plan, but produces less output. For example, look at Table 2-1. Notice that in Table 2-1, we have listed plans in order of increasing output; this imposes order and facilitates cost effectiveness analyses. For example, we are able to scan down the output column and find that Plan A and Plan B each produce 40 acres of output, but Plan B does so at a lower cost. If we are going to produce 40 acres of output, why do so for $20,000 when we can produce the same 40 acres for $10,000? Plan A is not cost effective.

Table 2-1 Cost Effectiveness Analysis		
PLAN:	TOTAL COST:	TOTAL OUTPUT:
No-Action Plan	$ 0	0 acres
Plan A	**$20,000**	**40 acres**
Plan B	$10,000	40 acres
Plan C	**$15,000**	**45 acres**
Plan D	$15,000	55 acres
Plan E	**$42,000**	**105 acres**
Plan F	$40,000	110 acres

Similarly, while Plan C and Plan D each cost $15,000, Plan D produces more output than Plan C. If we are going to spend $15,000 to produce output, why settle for the 45 acres attainable with Plan C when we could get 55 acres with Plan D? Plan C is not cost effective. Similar reasoning applies to the comparison of Plans E and F. Why would we produce 105 acres for $42,000 with Plan E when we could produce more acres of output (110) with Plan F for less cost ($40,000). Plan E is not cost effective.

We have just completed cost effectiveness analysis. The example in Table 2-1 demonstrates the three criteria for cost effectiveness screening. Again, these criteria suggest that plans be identified as non-cost effective if:

1. *The same output level could be produced by another plan at less cost*;
2. *A larger output level could be produced at the same cost*; or
3. *A larger output level could be produced at less cost*.

While the relationships outlined by the above criteria can be identified in Table 2-1, they can be made more visually apparent by graphing the output of each plan against the cost of each plan. This can be especially helpful in visualizing the relationships between cost and output across all plans when the number of plans under consideration becomes large. Figure 2-1 includes a *cost effectiveness frontier* graph for the plans in Table 2-1. In Figure 2-1, the "cost effectiveness frontier" is indicated by a line passing through all cost effective plans. Any plans above and to the left of plans on the "frontier" line are non-cost effective. The graph shows the difference in cost between Plans A and B, which each produce the same output level (40 acres); the difference in output between Plans C and D, which each cost the same ($15,000); as well as the reduction in cost concurrent with an increase in output as we move from Plan E to Plan F.

In this example, *all other considerations aside*, Plan A, Plan C, and Plan E (each shaded in Table 2-1, and above the cost effectiveness frontier in Figure 2-1) should be dropped from further analysis; they are not cost effective. But what about the selection decision from among the remaining, cost effective, plans: No-Action, Plan B, Plan D, and Plan F? Because each of these plans produce different levels of output, choosing from among them is making an output level selection. Choosing an output level is choosing the scale of the project. While total cost information is useful for screening out non-cost effective plans, in most cases, it should not be used as the basis for output level selection. In most environmental planning applications, decisions regarding the selection of output level can be facilitated by looking to *incremental cost* information.

INCREMENTAL COST AND INCREMENTAL OUTPUT IN INCREMENTAL COST ANALYSIS

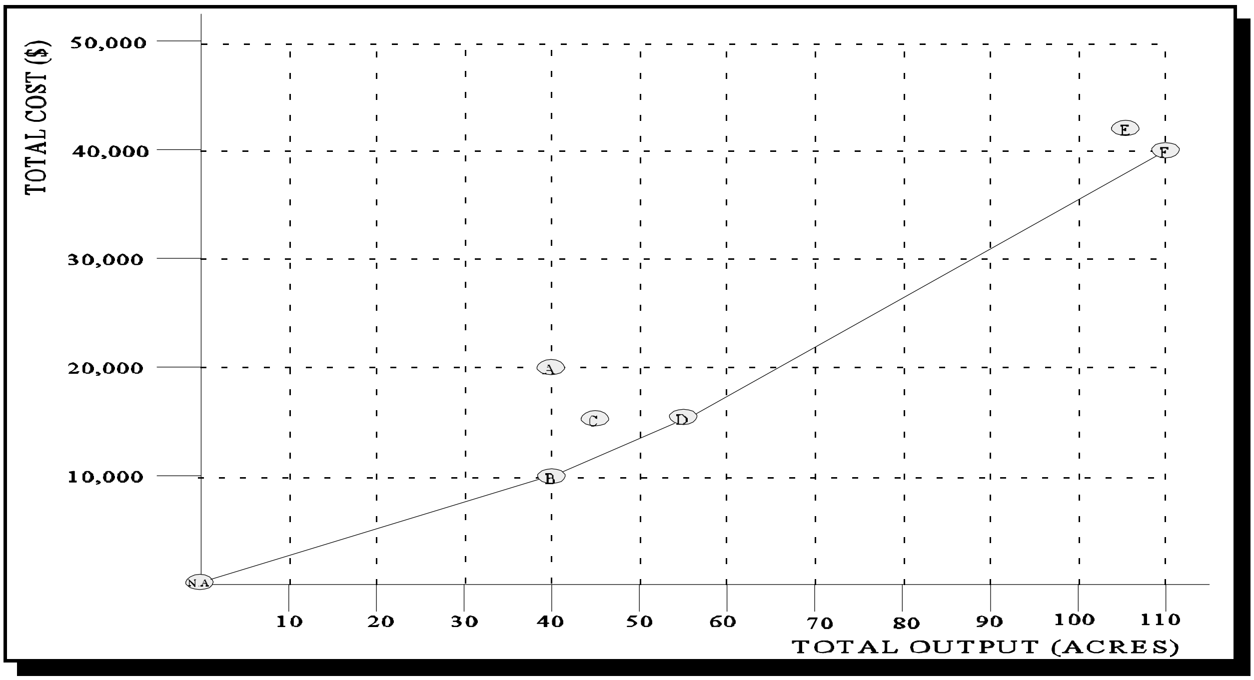


Figure 2-1 Cost Effectiveness Frontier

Let's return to the example of Table 2-1. Remember, we chose to drop Plans A, C and E from further analysis because they were not cost-effective. Table 2-2 contains the remaining plans, the No-Action Plan and Plans B, D and F, listed in order of increasing output. An additional column has been added to show the incremental cost of advancing from each output level to the next successive output level. Notice that for the No-Action Plan the concept of incremental cost is not applicable. Incremental cost shows the change in cost, in this case, from one output level to the next. Because the No-Action Plan entails making no changes, the concept of incremental values does not apply.

Table 2-2 Incremental Cost of Increasing Output to the Next Level			
PLAN:	TOTAL COST:	TOTAL OUTPUT:	INCREMENTAL COST:
No-Action Plan	$ 0	0 acres	not applicable
Plan B	$10,000	40 acres	$10,000
Plan D	$15,000	55 acres	$ 5,000
Plan F	$40,000	110 acres	$25,000

In Table 2-2, Plan B, the alternative with the lowest output level over the no-action plan, has an incremental cost of $10,000. This is the cost that results from the decision to implement Plan B instead of the No-Action Plan. It is computed by subtracting the cost of the No-Action Plan from the cost of Plan B. The incremental cost for the plan to provide the next successively larger level of output, Plan D, is $5,000. This is computed by subtracting the $10,000 cost of Plan B from the $15,000 cost of Plan D. Similarly, Plan F has an incremental cost of $25,000. This is computed by subtracting the $15,000 cost of Plan D from the $40,000 cost of Plan F.

Just as incremental costs show the change in cost resulting from a decision to implement one alternative instead of another, we can compute incremental output to show the change in output from one alternative to the next. Table 2-3 adds a new column to Table 2-2 for incremental output.

Table 2-3 Incremental Cost and Incremental Output of Increasing Output to the Next Successive Level				
PLAN:	COST:	OUTPUT:	INCREMENTAL COST:	INCREMENTAL OUTPUT:
No-Action Plan	$ 0	0 acres	not applicable	not applicable
Plan B	$10,000	40 acres	$10,000	40 acres
Plan D	$15,000	55 acres	$ 5,000	15 acres
Plan F	$40,000	110 acres	$25,000	55 acres

From looking at Table 2-3, we can now see that the decision to implement Plan B instead of the No-Action Plan will result in an additional (incremental) cost of $10,000 and provide additional (incremental) output of 40 acres. The decision to implement Plan D instead of Plan B would result in additional (incremental) cost of $5,000 and provide additional (incremental) output of 15 acres. Similarly, we can see that a decision to implement Plan F instead of Plan D would cost an additional (incremental) $25,000 and provide an additional (incremental) 55 acres. These incremental figures show us what additional cost will be incurred and what additional output will be gained as we step through each successive level of attainable output. This information could be used by decision makers to weigh whether the additional output provided by each successive output level is worth its additional cost.

It can be useful to apply the concept of average cost to incremental costs to calculate *incremental cost per unit* for each alternative plan. Remember, average cost is total cost divided by total output and shows the cost per unit for a particular output level. Similarly, average incremental cost, or incremental cost per unit, is computed by dividing incremental cost by incremental output. Incremental cost per unit shows the change in cost from one plan to another in a "per unit" basis. A column is added to Table 2-3 for incremental cost per unit in Table 2-4.

Table 2-4 Incremental Cost, Incremental Output, and Incremental Cost per Unit of Increasing Output to the Next Successive Level

PLAN:	COST:	OUTPUT:	INCREMENTAL COST:	INCREMENTAL OUTPUT:	INCREMENTAL COST PER UNIT:
No-Action Plan	$ 0	0 acres	not applicable	not applicable	not applicable
Plan B	$10,000	40 acres	$10,000	40 acres	$250/acre
Plan D	$15,000	55 acres	$ 5,000	15 acres	$333/acre
Plan F	$40,000	110 acres	$25,000	55 acres	$455/acre

The incremental cost per unit figures in Table 2-4 provide us with additional information that wasn't readily apparent in Table 2-3. For example, look at the incremental figures for deciding to implement Plan D instead of Plan B. As in Table 2-3, we can see that this decision would cost an additional $5,000 and provide an additional 15 acres, but the incremental average cost shows that those additional 15 acres cost $333 per acre; a relative increase in "per acre cost" from the first 40 acres we could get for $250/acre. Similarly, the decision to implement Plan F instead of Plan D will provide 55 additional acres at a cost of $455 each, another increase in "per acre cost" from the 15 additional acres provided by Plan D ($333/acre).

These incremental data are the types of cost and output data which are pertinent to output level selection decisions. From looking at Table 2-4, we can see that we can produce the first 40 acres at a cost of $250/acre. If it is decided that these 40 acres are worth $250 each ($10,000), then we must decide if 15 additional acres are worth $333 each (an additional $5,000). If it is decided that those 15 additional acres were worth $333 each, then we must decide if 55 more acres are worth $455/acre (an additional $25,000). This decision process can be facilitated by providing a graphic representation of the incremental cost and incremental output associated with each plan under consideration. Such an *incremental cost graph* is included in Figure 2-2.

Each "box" within Figure 2-2 corresponds to an individual plan. The width of each box represents the incremental output provided by implementing the corresponding plan instead of the plan preceding it (what additional output will be provided). The height of each box represents the incremental cost per unit of implementing the corresponding plan instead of the plan preceding it (the cost of each additional unit of output).

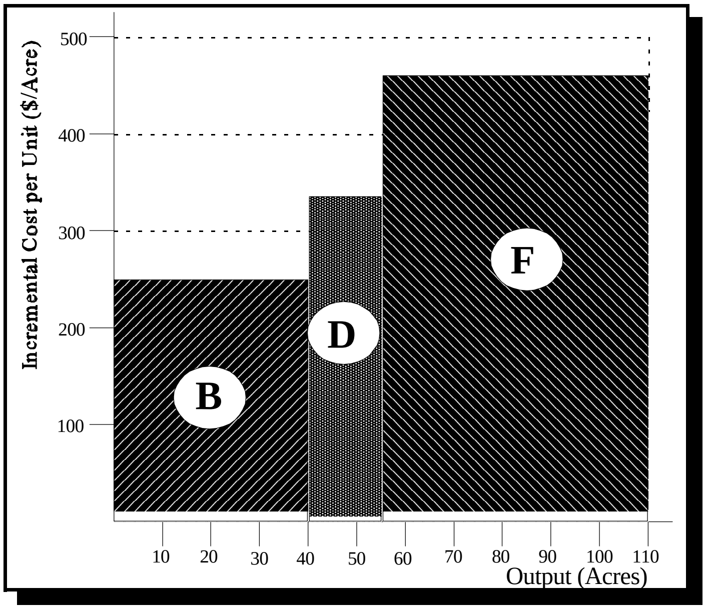


Figure 2-2 Incremental Cost Graph

By examining the graph, we can see we can get the first 40 acres for $250 each. If we want any more output, we can get 15 additional acres for $333 each. If we wish to increase project scale further, we can get 55 additional acres at a cost of $455 each. This type of incremental cost and incremental output information, along with descriptions of resource significance and other "unintended" effects of restoration plans, make up the types of information that can lead to better informed and supportable plan selection decisions.

AVERAGE COST VS. INCREMENTAL COST

A common misconception is that you should choose the plan (and thus the output level) which minimizes average costs (or, in other words, is most efficient in production). Such rationale for decision making is flawed. If minimizing average costs were the decision criteria, decisions would be made on the basis of cost alone and would overlook the important question of "*is this level of output worth it?*". If the answer is "*Yes*", perhaps then plans with higher average costs but that produce more output are also "worth it".

This concept is consistent with the NED objective of maximizing net benefits as opposed to maximizing the ratio of benefits to costs (the benefit-cost ratio). This "B-C ratio", by definition, is a plan's benefits divided by its costs. A B-C ratio of 1.0 signifies the "break-even point", where project benefits are equal to project costs. In planning for economic development, a plan must have a B-C ratio equal to or greater than 1.0 to be included in further analysis. Thus, the B-C ratio is used for screening alternative economic development plans. In economic development planning, plan selection is not based upon the relative magnitude of a plan's B-C ratio (total benefits/total costs). Rather, it is based upon the relative magnitude of the net benefits a plan provides, (total benefits - total costs).

A plan's average cost is, by definition, the plan's costs divided by the plan's benefits, or the cost per unit for a certain level of environmental output. Thus, average costs can be thought of as the ratio of costs to benefits; or, as the inverse of the B-C ratio, a "C-B ratio". Selecting a plan because it minimizes average costs in environmental restoration planning would be correlative to selecting a plan because it maximizes the B-C ratio in economic development planning, and could lead to improper decision making. Two examples illustrate this in Tables 2.5 and 2.6.

In Table 2.5, the plan that maximizes the B-C ratio is not the same as the plan that maximizes net benefits. If we were to select a plan based upon a decision criteria to maximize the ratio of benefits to costs, we would select Plan A, with a B-C ratio of 4. However, Plan B would provide $750 of net benefits over Plan A, and therefore is the economically optimal of the two alternatives. It is economically rational to choose net benefits of $1,500 over $750. Similarly, it is economically rational to increase the scale of production so long as *the incremental benefit of increasing scale exceeds the incremental cost of increasing scale*. The reasoning here is that so long as we are getting a positive return on additional investment, it is rational to increase production. We can see this is the case in Table 2-5 where deciding to implement Plan B provides $2,000 of incremental benefits for an investment (cost) of $1,250.

Table 2-5 B-C Ratio versus Net Benefits as Economic Development Plan Selection Rule

PLAN:	BENEFIT:	COST:	B-C RATIO: (BENEFIT/COST)	NET BENEFIT: (BENEFIT-COST)	INCREMENTAL BENEFIT:	INCREMENTAL COST:
No-Action Plan	$0	$0	not applicable	$0	not applicable	not applicable
Development Plan A	$1,000	$250	4.0	$750	$1,000	$250
Development Plan B	$3,000	$1,500	2.0	$1,500	$2,000	$1,250

Now, we will carry this type of example over to an environmental restoration planning situation in Table 2-6:

Table 2-6 Average Cost vs. Net Benefits as Environmental Restoration Plan Selection Rule

PLAN:	COST:	BENEFIT:	AVERAGE COST: (COST/BENEFIT)	NET BENEFIT: (BENEFIT-COST)	INCREMENTAL COST:	INCREMENTAL BENEFIT:
No-Action Plan	$0	0 acres	not applicable	?	not applicable	not applicable
Restoration Plan X	$100,000	500 acres	$200/acre	?	$100,000	500 acres
Restoration Plan Y	$250,000	1,000 acres	$250/acre	?	$150,000	500 acres

In Table 2-6, Restoration Plan X has a lower average cost than Restoration Plan Y; but does that mean it is a more economically desirable plan? From the amount of information given, we cannot tell which of the two plans is more desirable. We have shown, however, that the concept of average cost, (the ratio of cost to benefits) is the inverse of the concept of a B-C ratio (the ratio of benefits to costs). As such, minimizing average costs is correlative to maximizing a B-C ratio, and may not result in selecting the most desirable plan.

Table 2-5 demonstrated that a decision rule to select plans that maximize the B-C ratio can lead to economically improper decisions. Thus, it follows that a decision rule to select environmental restoration plans that minimize average costs could also lead to economically improper decisions. Such “economically improper decisions” may be, in effect, shortchanging the environment of additional restoration benefits that might be both desirable and economically justifiable. How then, do we know which plan maximizes net benefits for environmental restoration?

Notice that in Table 2-6, there are question marks in the column for net benefits. In economic development planning, the decision rule for plan selection is “choose the plan which maximizes net benefits.” When the benefits of environmental restoration plans are not measured in dollars, we cannot calculate net benefits. For example, look at Environmental Restoration Plan B in Table 2-2. We cannot subtract 1,000 *acres* from 250,000 *dollars* to derive net benefits; the units are incommensurable.

Thus, we are faced with a dilemma. We know that we shouldn't base decisions regarding plan selection upon average costs, yet we lack the capability of calculating net benefits upon which to base such decisions. This is the very evaluation dilemma that resulted in the requirement for incremental cost analysis in environmental plan evaluation.

Remember, in Table 2-5, it was shown that it is economically rational to increase the scale of production so long as *the incremental benefit of increasing scale exceeds the incremental cost of increasing scale*. The reasoning, that it is rational to increase production so long as we are getting a positive return on additional investment, is equally applicable to environmental restoration planning. The difference is that we are no longer comparing dollar incremental costs to dollar incremental benefits.

Now, we are comparing dollar incremental costs to non-dollar incremental units of output. Look at Table 2-6 for example. In the case of deciding whether we will implement the No Action Plan or Restoration Plan X, we must decide if the additional 500 acre benefit of implementing Restoration Plan X instead of the No Action Plan is worth its additional cost of $100,000. Similarly, if we are choosing between Restoration Plan X and Restoration Plan Y, we must decide if the additional 500 acres provided by implementing Restoration Plan Y instead of Restoration Plan X is worth its additional cost of $150,000. Such choices require that decision makers base subjective judgments about the value of the output being produced on additional information generated outside the framework of cost effectiveness and incremental cost analyses; (for example, information pertaining to the relative scarcity of the output, and the significance of the output).

Cost effectiveness and incremental cost analyses will not, by themselves, result in a unique plan recommendation. The tools are useful, however, in providing information to support plan selection. While cost effectiveness and incremental cost analyses provide needed tools for plan evaluation, the analyses are dependent upon inputs from various other phases of the planning process. It is important that all members of a study team understand how their individual pieces come together with those of other disciplines to accomplish plan evaluation. The processes by which the different phases of environmental planning relate to one another and culminate in plan recommendation are the subject of the remainder of this chapter.

ENVIRONMENTAL PLANNING

Environmental planning within the Corps is concerned with the restoration or mitigation of scarce natural resources. For a biologist, these planning concerns might well be involved with the propagation of fish and wildlife species. For example, how can we provide habitat for striped bass in the Chesapeake Bay? An economist looks at the same species propagation as a production problem. For example, what are the least costly techniques for *producing* striped bass habitat in the Chesapeake Bay and how much habitat should be produced?

Planning is a formal choice process that integrates many perspectives. Engineering, economic, environmental, social, and political concerns are brought to the table and traded off as a number of alternative plans are formulated and evaluated. As part of this process for environmental planning, cost effectiveness and incremental cost analyses are useful for the evaluation of alternatives and justification of recommended plans.

The P&G planning process consists of a series of steps that provide an orderly and systematic approach to selecting a recommended plan. Plan formulation and evaluation is a dynamic process, the steps of which may be iterated one or more times as steps of the process uncover new information, new alternatives are developed, or as objectives are reevaluated. This planning process is equally suited to economic development or to environmental restoration projects. The planning process is the same, it is the projects' objectives and methods of evaluation that are different. The P&G planning process consists of the following major steps:

1. Identify Problems and Opportunities;
2. Inventory and Forecast Without-Project Conditions;
3. Formulate Alternative Plans;
4. Evaluate Effects of Alternative Plans;
5. Compare Alternative Plans; and
6. Plan Selection.

Each step of the planning process provides information needed for the steps that follow. When planning for the restoration of environmental resources, cost effectiveness and incremental cost analyses may be used as tools for the comparison of alternative plans. Importantly, the four previous steps of the planning process build upon one another to provide the input necessary to conduct these analyses. If the planner understands what data are required for the analyses and how those data are to be used, thinking of the cost analyses' requirements through each prior step of the process can help to gather the appropriate data and organize them in a useful format; not only for the cost analyses, but also for other analyses and for communications. Let's look briefly at each step of the planning process and examine the relationships between steps, and ultimately with the cost effectiveness and incremental cost analyses processes:

1. Identify Problems and Opportunities: A list of resource problems and opportunities can be compiled using analyses of information from initial scoping efforts, and information on prior ecological conditions. Significant issues to be addressed as well as the range of those issues should be identified. A simple example of the results at the problem/opportunity identification stage would be the identification of a decline of waterfowl numbers at site *X*.

2. Inventory and Forecast Without-Project Conditions: Inventory and forecasting should include an analysis of the identified problems and opportunities and their implications for the planning setting. Resource inventories should be limited to resources affecting the problems or opportunities or likely to be affected by alternative plans. The inventory does not necessarily include an exhaustive listing of all resources in the area. This inventory should describe the existing conditions and should be the baseline for forecasting with- and without-plan conditions. This analysis should be used to redefine the previously specified problems and opportunities in terms of specific planning objectives.

Planning objectives are specific statements of purpose that follow from the screening of problems and opportunities. Planning objectives establish the desired directions of change in the environmental resources under study. The objectives must be stated in measurable terms, but are not targets for particular outcomes. To continue with our example of waterfowl, where we identified the problem of a decline in waterfowl numbers, examples of planning objectives might be to increase the population of mallards at site X, or similarly to increase the habitat for mallards at site X. The objectives should cite the units of measurement (in our example we might use the measurement units of either number of breeding pairs, or habitat units, respectively) to be used to evaluate the contributions that proposed actions make toward the stated objective. Planning objectives must have enough specificity in their statement to permit the development of particular alternatives in Step 3.

3. Formulate Alternative Plans: Plan formulation is simply the development of alternative ways (plans) to accomplish the restoration or mitigation objectives. Plan formulation should consider all the management measures available for addressing the planning objectives. Combinations of management measures, defined as plans, will achieve different levels of satisfaction for each objective. For example, alternative plans for increasing mallard duck populations (or alternatively, habitat for mallard ducks), might include different combinations of the management measures: water level control; vegetative planting; and creation of nesting sites. These alternative plans will be evaluated with the cost effectiveness and incremental cost analyses procedures based upon estimates of their respective cost and output. The effort required for cost effectiveness and incremental cost analyses may be minimized in some cases if cost effectiveness analysis is performed on individual management measures in the formulation of cost effective plans.

4. Evaluate Effects of Alternative Plans: The terms used in production economics describe this planning step. Alternative plans were formulated in Step 3 by combining resources and management measures (inputs). The alternative plans produce different levels of satisfaction of the planning objectives (outputs). Thus the relationship between alternative plans and the accomplishment of planning objectives can be characterized as a production function. Explicit determination of this relationship of inputs to outputs (production function) is the subject of this step.

Determining the effects of proposed alternative plans requires the forecasting of future with- and without-plan conditions. The with-plan conditions are compared to without-plan conditions to determine the effects of each plan. It is these effects that are weighed with their costs of production in cost effectiveness and incremental cost analyses. For each "with-plan" analysis, two types of effects have to be estimated; monetary effects (costs) and environmental effects (outputs). Estimates of the costs of plans will typically come from engineering, real estate, and economics elements. Estimates of the outputs of plans will typically come from environmental staff elements.

The appropriate tools for the measurement of environmental outputs will depend on the resources under study. However, in all cases, the measurement of outputs will require that some specific *indicator* and *unit of measurement* be determined. An indicator is a characteristic of an environmental resource that serves as a direct or indirect means of measuring or otherwise describing changes in the quantity and/or quality of the resource. For each environmental resource, one or more indicators of quantity or quality should be specified, along with the unit of measurement to be associated with each indicator. To continue with our example, accomplishment of the planning objective: "to increase the population of mallard ducks at site X" might be determined by the indicator, "mallard duck habitat" which, in turn, could be measured in the unit, "habitat units".

5. Compare Alternative Plans: Plan evaluation involves comparison of the effectiveness and efficiency of alternative plans in accomplishing the planning objectives. In environmental planning, this is the step in which cost effectiveness and incremental cost analyses can play a central role by providing information to assist in plan evaluation. In order to conduct the cost analyses, however, information derived from the previous steps in the planning process must be available. Therefore, a good incremental analysis is dependent on proper and complete planning.

The purpose of evaluation is to determine whether specific alternatives are "worth" pursuing. The cost analyses facilitate this decision by organizing information for each alternative in a format such that changes across alternatives are made apparent and comparable. This information is concerned with both *inputs* and *outputs* - where "inputs" refers to the costs associated with each alternative plan, and "outputs" refers to the levels of accomplishment of objectives, measured in specified units of defined indicators, of each alternative.

6. Plan Selection: Although cost effectiveness and incremental cost analysis do not provide a discrete decision criterion (such as the maximizing of net benefits in NED analysis), they do provide for the explicit comparison of the relevant changes in cost and environmental outputs upon which such decisions may be made. Because the techniques do not directly measure the value of the environmental benefits, they will usually not lead to a single best solution. They do improve plan selection for environmental restoration or mitigation by ensuring that a rational, supported, focused and traceable approach is used for considering and selecting from among alternative methods to produce environmental outputs.

It is by considering the information assembled by the cost analyses in combination with other "subjective" information pertaining to resource significance and, where appropriate, descriptions of other "unintended" effects, that tradeoffs can be made across different alternatives and a preferred alternative can be selected. The presumption is that the information provided by the cost analyses will inform decision makers who can then weigh the merits of alternative plans.

While the cost effectiveness analysis and incremental cost analysis computations and evaluation of results take place in the later stages of planning, it is clear that the analyses are dependent on data generated in the stages that precede it. Having an understanding of the data requirements for cost analysis early in the planning process can ease the level of effort required later for gathering and organizing the necessary information for the analyses. Understanding that the analyses require clear measures of changes in specific outputs assists in the articulation of proper planning objectives whose efficiency and effectiveness can be evaluated. Organization of alternative plans and their respective changes in project outputs and costs, while necessary for the cost effectiveness and incremental cost analyses procedures, also provides a rational and traceable decision path. This organized information can then be used in the analyses and can provides documented support for improved decision making and plan recommendation.

DECISION CRITERIA

For all types of projects, the P&G defines four broad decision criteria for the evaluation of all plans: *completeness*; *effectiveness*; *efficiency*; and *acceptability*. Completeness is the extent to which a given plan provides and accounts for all necessary investments and other actions to ensure the realization of the planned effects. Effectiveness is the extent to which an alternative plan accomplishes its planning objectives. Efficiency is the extent to which an alternative plan is the most cost-effective means of accomplishing its planning objectives. Acceptability is the workability and viability of the alternative plan with respect to acceptance by state and local entities and the public and compatibility with existing laws, regulations, and public policies.(USWRC 1983)

For traditional projects (flood damage reduction, navigation), the NED objective (maximization of net benefits) ensures that the efficiency criterion has been met. The alternative which maximizes the net benefits of the project (total benefits - total cost) is the alternative which meets this criterion. However, such a selection criterion falls short for environmental projects because of the difficulties in quantifying project benefits in monetary terms. Without a reliable monetary estimate of project benefits with which to compare monetary costs, it's not possible to determine the alternative plan that maximizes net monetary benefits. However, this does not mean that the economic efficiency of environmental plans cannot be evaluated.

The tool of cost effectiveness analysis enables planners to impose economic efficiency on the cost (production) side of the equation by assuring that a range of cost effective plans are identified. This economic tool can ensure that either a set level of environmental output is produced in the least cost possible, or that for a set level of expenditures, environmental output production is maximized. Although the cost analyses do not provide a discrete decision criterion (such as the maximization of net benefits in NED analysis), incremental cost analysis provides for the explicit comparison of the relevant changes in costs and outputs on which such decisions may be based.

CHAPTER SUMMARY

Cost effectiveness analysis and incremental cost analysis are rooted in economic production theory and utilize such economic principles as scarcity and choice and opportunity cost. The cost analyses examine changes in cost and output that result from decisions to implement alternative plans and plan components. Cost effectiveness analysis can be utilized to meet several different needs. It may be conducted on individual management measures to guide the formulation of cost effective plans. When plans are formulated based upon criteria other than the cost effectiveness of their components (management measures), cost effectiveness analysis can be used to identify the least-cost plan for producing every attainable level of environmental output, as well as for identifying those plans where more output could be produced for the same or less cost. Incremental cost analysis can assist in determining the appropriate scale of mitigation or restoration by revealing variations in cost across alternatives; explicitly asking for each attainable increment of output: “is it worth it?”. Thus, the cost analyses procedures provided in this manual can assist in the evaluation of alternative restoration or mitigation plans.

The P&G planning framework provides environmental planners with a structured analytical process for formulating and evaluating environmental mitigation and restoration plans. Unlike traditional economic development planning studies, environmental planning studies lack a discrete decision rule for plan selection. This is tied to the difficulty in measuring the outputs of environmental plans in monetary terms. The procedures of cost effectiveness analysis and incremental cost analysis provide planners with an organized process for examining the economic efficiency of alternative plans for the production of environmental outputs. The cost analyses provide information to assist in and support decision making and plan recommendation.

CHAPTER 3
ENVIRONMENTAL PLAN FORMULATION AND EVALUATION

"The challenge in restoration management is to evaluate trade-offs not only between restoration and the current state of the aquatic ecosystem, but also between alternative approaches to restoration. In lieu of benefit-cost analysis, the committee proposes a decision making approach based on opportunity cost. Confronting the decision process with cost information elicits its 'values' from that process. Continually questioning the value of restoration by asking whether an action is 'worth' its cost is the most practical way to decide how much restoration is enough."
National Research Council, Committee on Restoration of Aquatic Ecosystems; Restoration of Aquatic Ecosystems; 1992.

INTRODUCTION

Cost effectiveness analysis and incremental cost analysis are plan evaluation tools to facilitate good decision making and communication. The tools themselves will not identify a unique solution for plan selection. They do however provide a framework of organized information with which to communicate the differences across the alternatives under consideration. These differences are discussed in terms of variations in output levels and in costs. Organized information about alternative levels of output and their associated cost is useful both for making selections as to project scale and in describing the rationale for that selection.

The purpose of this chapter is to expand upon the framework for conducting cost effectiveness and incremental cost analysis for environmental projects presented in Chapter Two. The techniques presented in this chapter are flexible and can handle planning settings of various levels of complexity. To demonstrate the application of this analysis framework, we will build upon an example of an environmental restoration study, and show how analytical techniques can be introduced to assist in both the *formulation and evaluation* of alternative restoration plans. First however, it will be useful to discuss some terminology that will be used throughout the Chapter, as well as some other issues that, while peripheral to the analyses, have important implications on their execution.

TERMINOLOGY

Throughout this Chapter, we will make use of the economic terminology introduced and defined in Chapter Two. Specific economic terms that will be discussed are: *total cost*, *average cost*, *incremental cost*, *incremental cost per unit* and *production efficiency*. These economic concepts will be used in describing the cost of producing different levels of output. We will use the term *solutions* to generically refer to methods of such production. While the term "solution" is useful for generally describing methods of producing outputs, it is necessary to introduce two distinctions within the category of solutions: *plans* and *management measures*.

We will use the term "plan" as it is typically used in water resources planning. Sometimes plans are thought of as "alternatives" or "alternative plans". In this Chapter we will use the term "plan". Plans are made up of one or more "management measures". When selecting from among a range of plans, the selection of any one plan should preclude the selection of any other plan. Thus, plans within a single planning study are *mutually exclusive*.

While plans are mutually exclusive, their components (management measures), may or may not be *combinable* with other management measures or plans. Management measures are the individual, separable, actions that can be taken to affect environmental variables and produce environmental outputs. A management measure is typically made up of one or more *features* or *activities* at a particular *site*, intended to cause a desirable change in an output. The distinction between "features" and "activities" is that a feature is typically a structural element requiring construction, and an activity is typically some nonstructural, ongoing (continuing or periodic) action. A "site"is the place (land and water at, above, and below the surface) where a feature or activity is located.

A management measure may or may not be able to stand alone as a plan; it depends on the characteristics of the management measure. Some management measures may be considered in different sizes, or *scales*. For example, the management measure "levee" might have several different scales pertaining to different levee heights. Scales of a single managment measure are mutually exclusive (for example, we must decide upon one levee height). Therefore a plan may only contain one scale of a given management measure. Examples of management measure scaling in environmental planning might include: number of plantings per acre; % canopy cover of vegetation; water depths; or discharge capacity of a pump. Some environmental measurement methods (for example, HEP), can be helpful in defining scales. The production function equations contained in such models often identify minimum, maximum, and optimal levels of particular environmental variables for a particular species. Those levels may provide a basis for identifying corresponding scales of management measures.

Throughout the remainder of this text, whenever we use the term "solution", it implies that the discussion applies to both plans and management measures. This chapter's classification of production methods (solutions) into plans and management measures is necessary for describing analytical approaches to *plan formulation*. However, in gaining an understanding of the *plan evaluation* processes of cost effectiveness and incremental cost analyses, it may help to concern ourselves not with what management measures make up each plan, but rather, only with the cost incurred and output provided by each plan.

Some scenarios involve the selection from among a range of recommended plans at independent sites all producing the same units of output. We will call such multi-site scenarios as *programs*. For example, project proposals (the recommended plan at each site) submitted for funding under the Coastal Wetlands Planning, Protection, and Restoration Act, sometimes called the "Breaux Bill", are prioritized based upon their relative production efficiency (determined by comparing their unit costs of producing output). In order to obtain uniform quantified output measurements across all sites within this program, the Wetland Value Assessment methodology was developed which measures the output at each site in the same units (Mitchell 1991). The purpose of programmatic plan evaluation will often be to determine the order of project implementation. For example, within the "Breaux Bill" program, sites are implemented in order of their production efficiency until budget constraints are reached.

Thus, we have *management measures* which make up *plans*. Plans are then evaluated at the site level through cost effectiveness and incremental cost analyses and a recommended plan is selected. In some cases, recommended plans from different sites make up a *program*. Where the recommended plan at each such site within a program is measured in the same units, then cost effectiveness and incremental cost analysis can be applied in programmatic evaluation. In the remainder of this chapter we will provide methods for: formulating *plans* by combining *management measures*, performing cost effectiveness and incremental cost analyses to evaluate plans at the *site level*, and also at the *programmatic level*.

SELECT ISSUES AND CONSIDERATIONS

DATA REQUIREMENTS

Cost-effectiveness and incremental cost analyses require no additional data than should be generated in a typical planning study. The analyses combine, sort, compare and interpret information about the cost and output of solutions. As such, the analyses require three types of data: a *list of solutions*, and for each, an estimate of the *cost* and the *output*.

While these three types of information comprise all the input required to conduct the cost analyses, arriving at each of these input components involves many challenging issues. Issues that, while not specific components of the cost analyses, must be addressed for the results of the analyses to be meaningful. For example, before we can conduct the cost analyses, a list of plans must be developed through plan formulation. Future without-project conditions must be forecast as the basis for cost and output estimates for each plan. Plan formulation, as well as the estimation of the cost and output of those plans, can be steeped in some complicated and confusing issues. While addressing all such issues are beyond the scope of this manual, we should discuss a few.

PLAN FORMULATION

The first issue concerns plan formulation. When formulating plans, it is important that we derive a range of *independent* and *mutually exclusive* plans. Independence means that implementation of any plan under consideration should not be dependent on the implementation of any other plan or management measure. If a management measure has the quality of independence, then it may also be considered a stand alone plan. Mutual exclusivity means that the selection of any plan should preclude the selection of all others.

Where do alternative plans come from? There are many approaches to plan formulation. For the purpose of this manual, we will discuss three broad "approaches" to developing alternative plans and their relationships to cost effectiveness and incremental cost analyses. These approaches can be categorized as follows:

- "Plans Developed by Others";
- "Ask an Expert"; and
- "Assemble all Possible Combinations of Management Measures".

"Plans of Others"

This category is not actually an approach to plan formulation. Rather, it describes cases where the analyst(s) responsible for performing cost effectiveness and incremental cost analyses was not involved in plan formulation. In such situations, the analyst(s) is not directly concerned with how a set of plans was formulated, but only in performing the cost analyses on those plans. This category might also include plans introduced from outside the planning team. Examples could include plans introduced by a local sponsor, interest group, or another Federal agency. The analytical techniques of cost effectiveness and incremental cost analysis introduced in Chapter Two and described in additional detail later in this Chapter can be applied to such situations so long as the plans are independent and include comparable cost and output estimates.

"Ask an Expert"

This approach to plan formulation utilizes the professional judgment and informed personal intuition of "experts" in appropriate disciplines. This process of consulting the appropriate technical experts and coming up with alternative plans has been a typical approach to plan formulation within the Corps. Examples of technical experts may include in-house Corps experts (for example, in hydraulic design, civil engineering, landscape architecture, agronomy, and other design arts and sciences); consultants (for example, architectural/engineering firms and universities); experts in other agencies (Federal, state and local); and other interest groups outside government. As with "Plans from Others", the plans arrived at through this process can be evaluated using the cost effectiveness and incremental cost analyses procedures introduced in Chapter Two and described in further detail later in this Chapter so long as the plans are independent and include comparable cost and output estimates.

"Assemble All Possible Combinations of Management Measures"

This approach to plan formulation begins with a list of individual management measures and formulates plans by deriving every possible combination of those measures. The resulting set of combinations is the entire set of possible alternative plans that can be generated from the measures under consideration. The individual measures might be identified by either of the two previously described "approaches" to plan formulation. Once all possible plans (given a fixed set of management measures) have been identified, they can be evaluated using the cost effectiveness and incremental cost analyses procedures introduced in Chapter Two and described in further detail later in this Chapter so long as the plans are independent and include comparable cost and output estimates. The procedures for applying this approach to plan formulation will be described in further detail later in this chapter.

RELATIONSHIPS AMONG MANAGEMENT MEASURES

Plan formulation requires an understanding of the relationship of specific management measures to one another. As discussed in Chapter Two, a study's planning objectives can be used to identify management measures. For example, "Given the objective to restore populations of mallard ducks at Site X, what specific management measures can be taken to meet this objective?" Resulting measures, in a variety of sizes and configurations, can then be used as the building blocks of alternative plans. Determining the configurations of management measures that can be combined into plans requires an understanding of the relationships between those measures.

Combinability Relationships

When formulating plans, it is important to have an understanding of which of the management measures under consideration can be combined with specific other measures. For example, active management measures like planting and construction of a berm for inundation may not be combinable with a passive approach that relies on natural vegetation. In this example, there is a conflict between an active and a passive approach; the approaches are mutually exclusive, that is, one precludes the other.

Making determinations about what measures can and cannot be combined are often complex decisions that may require participation by a variety of disciplines, including hydraulic and design engineers, landscape architects, biologists and others with practical knowledge and experience related to the solutions under consideration. Analysis of management measures to separate those that are combinable from those that are mutually exclusive becomes especially important when using the "Assemble All Combinations of Management Measures" approach to plan formulation.

Dependency Relationships

For a management measure, or a combination of measures, to be considered a plan, it must be able to stand alone. In other words, implementation of the plan must not be *functionally dependent* on the implementation of any other plan or measure. Functional dependence refers to a relationship between two or more measures such that any or all of the measures will not function as intended without the presence of one or more of the other measures. Dependency can occur in different ways. We will discuss several different dependency relationships.

One example of dependency is where two or more measures must be implemented in combination or not at all. Such dependence can be described as *mutual dependency*. For example, consider the following two management measures:

- Management Measure [A] = Vegetative Planting;
- Management Measure [B] = Irrigation System.

If [A] will not work without [B], then [A] cannot stand alone and cannot be a plan. Similarly, if [B] is only included because of the existence of [A], then [B] cannot stand alone as a plan. Here only the combination [A+B] is a viable plan. In cases where we have mutual dependency, it is best to group the two measures together and think of them as a single measure for the purposes of analysis. For example, in this case we could group management measures A and B together as a new measure C such that:

- Management Measure [C] = Planting & Irrigating.

A different type of dependency is where some measure(s) are dependent upon other measure(s) but the relationship is not reciprocal. We will refer to this type of dependency as *path dependency*. Understanding path dependency relationships can help to assure that time and resources are not wasted evaluating plans that could not be implemented because they fail to meet a dependency path requirement. For example, consider a case where we have five management measures: A, B, C, D, and E. In this example, we must implement A before implementing B; if A and B are both present, we can then add C. Also, D must be present before we can add E. It can be helpful to map out such dependency relationships in a *dependency path diagram* such as that in Figure 3-1.

Examining Figure 3-1, we can see that B is dependent on A; C is dependent on both A and B; and E is dependent on D. The dashed line between A and D indicates that the two are not dependent but can be combined. Recognizing dependency relationships among management measures can assist in screening out plans that are

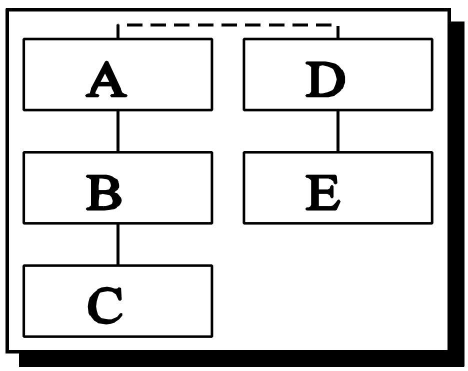


Figure 3-1 Dependency Path Diagram

not feasible because they fail to meet dependency requirements when using the "all combinations of management measures" approach to plan formulation. In our example, there are 32 possible combinations of the management measures A-E. However, many of these possible combinations are not functionally feasible because they violate dependency path requirements. Table 3-1 includes all combinations with shading over those plans which are not feasible because they do not meet dependency path requirements. Out of the initial 32 possible plans, only 12 meet dependency path requirements and are functionally feasible.

Table 3-1 All Combinations of Management Measures
(with shading over plans which do not meet dependency path requirements)

NO COMBINATION	AD	ABC	**BDE**
A	**AE**	ABD	**CDE**
B	**BC**	**ABE**	ABCD
C	**BD**	**ACD**	**ABCE**
D	**BE**	**ACE**	ABDE
E	**CD**	ADE	**ACDE**
AB	**CE**	**BCD**	**BCDE**
AC	DE	**BCE**	ABCDE

Dependency path requirements may not always be as straightforward as the relationships depicted in Figure 3-1. Those relationships consist of "straight-line" dependencies, where all dependencies occur in the same "dependency paths". Situations may arise where we are faced with *"either...or"* dependencies. "Either...or" dependencies occur where a common measure may be added to more than one dependency path. For example, consider that on a common plot of land we have two measures: P_1 - to plant one type of vegetation and P_2 - to plant a second type of vegetation. Assume that we could plant either alone, or both in combination. If we were to add to either (or both) planting measures a new measure: F - to fertilize; we would then put the same measure in two dependency paths. These paths are depicted in Figure 3-2.

Now, we can add measure F (fertilize) if *either* G *or* T is present. Similarly, F could be added if *both*

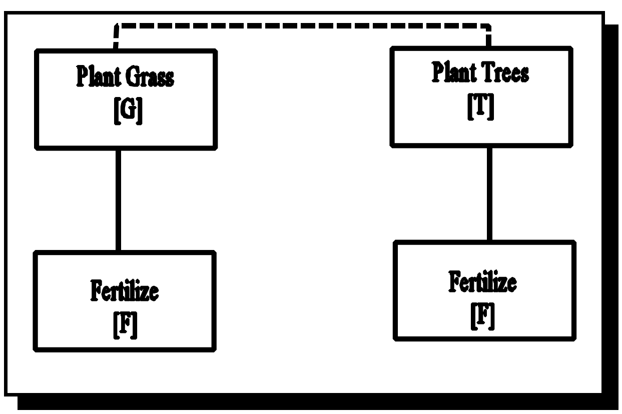


Figure 3-2 Example of "*Either...Or*" Dependency

G and T are present. In this case, we might only incur the cost of fertilizing once, but the effect of fertilizing on the planting may vary depending upon whether one or two types of planting are being effected. In such cases, the potential for improper estimates (either of cost, output, or both) is high. Where "either... or" dependencies occur between management measures, it is important to check the validity of the cost and output estimates of all combinations that include those measures. This issue will be discussed further in the section on "Additive Cost and Output Estimates".

COST AND OUTPUT ESTIMATION

When estimating the cost and output effects of solutions, all cost and output estimates need to be measured over the same time period and in the same unit of measurement. That is, outputs *and* costs can be estimated either on an average annual ("annualized") output and cost basis, or on a total output and total cost basis; either is acceptable (although average annual is more frequently used) so long as both the outputs and the costs are comparable.

Standard discounting procedures will be used in developing the average annual equivalent cost or total present worth cost estimates, based on the appropriate Federal discount rate established for the evaluation of water resources development projects. A comparable "discount rate" is not available for environmental outputs. Therefore, while cost estimates should be discounted, output estimates should either be: a) summed over the time period being considered for an estimate of total output; or b) summed and divided by the number of years in the time period for an estimate of average annual output. The Bussey Lake Demonstration Study provides examples of the estimation of both average annual cost and output (Carlson 1993).

INCOMMENSURABLE OUTPUT MEASUREMENTS

In a single planning study, it is most desirable if the environmental outputs of all alternatives are measured in like units; otherwise we are left trying to compare "apples and oranges". Output estimates may be measured in acres, habitat units, population counts, or any other cardinal units of measurement that are consistent across solutions. It is typically more meaningful to make comparisons of alternative solutions that all produce the same type of output (for example, habitat units for mallard ducks); it is typically less meaningful to directly compare one solution producing output measured in *habitat units for mallard ducks* to another solution producing output measured in *acres of wetlands*.

Similarly, it is less meaningful to compare different alternatives which produce habitat units for different species; for example a plan to produce *habitat units for mallard ducks* and a plan to produce *habitat units for sea turtles* are not directly comparable. Here, we say "*directly* comparable" because it is possible to evaluate different outputs measured in different units, but other processes must be utilized. For example, each species could be evaluated separately, and the results of each analysis could be presented to decision makers to support tradeoffs. Decision makers, stakeholders, and technical experts might also come to an agreement as to acceptable formulas, tailored to a specific planning study, for combining unlike units.

ADDITIVE COST AND OUTPUT ESTIMATES

Another issue which should be addressed is the concept of *additive outputs* and *additive costs*. It may appear intuitive that to arrive at estimates of the cost and output resulting from a plan, that we can sum the costs and outputs produced by each separable component (management measure) within that plan. While this assumption may be acceptable in certain situations, it is not always the case. For example,
look at an example where we have an alternative plan, Plan A, that is made up of three management measures such that:

Plan A = Fencing + Planting + Fertilizing

The outputs of [Fencing + Planting + Fertilizing] in combination may not be equal to [The Outputs of Fencing] + [The Outputs of Planting] + [The Outputs of Fertilizing]. The cumulative effects of the management measures in combination may differ from the sum of the singular effect of each management measure evaluated as if it were to "stand alone" because of the production function relationship for the particular output being produced. Similarly, the cost of [Fencing + Planting + Fertilizing] may differ from [The Cost of Fencing] + [The Cost of Planting] +[The Cost of Fertilizing]. For example, if we estimate the costs for each plan component one at a time, we might include some costs (for example, mobilization) for each component that might only be incurred once, reducing that aspect of cost by possibly 1/3 for each component when combined.

Depending on the planning setting, it may be acceptable to assume that costs and outputs are additive. The additive assumption is particularly helpful in early planning iterations where there may be a very large number of alternative plans to analyze. It's usefulness decreases as the number of plans is narrowed and more precise cost and output estimates are needed for decision making. In any case, it is important that this issue be examined on a case by case basis to assure that the inputs into the analyses (the cost and output of alternative plans) are the best estimates we can get. An important point that should be stressed is that while the measurement of plan effects is outside the analytical framework of cost effectiveness and incremental cost analyses, the significance of the analyses' results are dependent upon the results of these preliminary planning steps. Because the "assemble all combinations of management measures" approach to plan formulation lends itself to making the "additive assumption", special attention to checking the validity of cost and output estimates of plans generated through this process may be appropriate.

INCIDENTAL BENEFITS

Before turning to a discussion of the methods for conducting cost effectiveness and incremental cost analyses for environmental planning, one final economic issue, *incidental NED benefits,* needs to be addressed. Incidental NED benefits are NED benefits, in the same eleven categories previously listed in Chapter 2, on page 11, which occur as an unintended consequence of an environmental restoration or mitigation plan incurring *no additional* implementation or OMRR&R costs. In some ways they can be considered the opposite of opportunity costs.

Although incidental benefits are not costs, ignoring them in cost effectiveness and incremental cost analyses can lead to less than optimal decisions. For example, consider a case where we are planning to restore wetlands. We have proposed two sites for this restoration; one lies above a town, the other below. If each site would provide the same amount of environmental restoration outputs at the same cost, but the site above the town would also provide some incidental flood damage reduction benefits, the site above town would be considered more desirable, all other things being equal.

One analytical approach that can be used to account for incidental benefits in the cost effectiveness and incremental cost analyses is to treat them as a negative cost (opposite of opportunity cost). They would then be subtracted from the implementation and OMRR&R costs for a new estimate of total cost. However, this can only be done if the benefits are incidental, in terms of all alternatives being considered. For example, consider again the two alternative sites being considered for wetland restoration. Again, both provide the same level of restoration outputs. This time, however, the site above the town costs $100,000 more and also provides $200,000 of flood damage reduction benefits. Although this alternative may be more desirable in terms of total outputs and costs, the flood damage reduction benefits are no longer incidental in terms of comparison with the other plan. The additional cost of $100,000 does not provide any additional restoration output, only flood damage reduction benefits.

It is for the above reason that when evaluating restoration or mitigation projects, initial cost effectiveness and incremental cost analyses should be conducted using only the implementation, OMRR&R and, where applicable, opportunity costs. Subsequent analyses can be conducted subtracting incidental or other benefits in the calculation of total costs. Such analyses will provide additional information to sponsors and other stakeholders about the options available to them, but it also introduces plan formulation and cost sharing issues that are beyond the scope of this manual.

EXAMPLES: PLAN FORMULATION AND EVALUATION

Cost effectiveness and incremental cost analyses are tools which can be applied for the evaluation of alternative environmental restoration plans. The procedures and techniques for conducting cost effectiveness and incremental cost analyses are basically the same for all planning settings. There are, however, different approaches to plan formulation. The remainder of this chapter will step through two different approaches to plan formulation and show how cost effectiveness and incremental cost analyses can be applied to the resultant plans. We will also discuss how the analyses can be applied to alternative plans without attention to the methods by which those plans were formulated.

One approach to plan formulation is based upon the relative production efficiencies of individual management measures. This approach results in the derivation of a range of cost effective plans and eliminates the need for cost effectiveness screening of those plans prior to incremental cost analysis. This approach can be the simplest in some situations. However, the gains in analytical simplicity can come at the cost of unrevealed information and the requirement of the limiting assumption that the cost and output estimates of management measures are additive. Also, this method becomes less straightforward when we introduce alternative scales of management measures.

A different approach to plan formulation, which also begins with a list of individual management measures, formulates alternative plans by deriving every possible combination of those management measures.

Then, cost effectiveness analysis is employed to screen out non-cost effective plans prior to conducting incremental cost analysis. This is the plan formulation approach outlined in *Cost Effectiveness Analysis for Environmental Planning: Nine EASY Steps* (Orth 1994). While this approach involves more complex procedures, the added information that can be provided may well be worth the added analytical effort required. Also, this approach is not limited by requiring the assumption that the cost and output estimates of management measures are additive and allows the consideration of alternative scales of individual management measures.

In some cases, analysts with the responsibility for performing plan evaluation may not be involved in plan formulation. In other cases, instead of starting with a list of individual management measures and then deriving possible combinations (plans), we start with a discrete range of alternative plans. These plans could be arrived at by a series of processes. In settings like these, the analyst may not be directly concerned with how the plans were formulated, but only in performing cost effectiveness and incremental cost analyses on those plans. The same procedures for conducting cost effectiveness and incremental cost analyses introduced in Chapter Two and discussed in further detail in the two examples to follow can be applied in such plan evaluation settings.

USING THE PRODUCTION EFFICIENCY OF MANAGEMENT MEASURES IN PLAN FORMULATION

In this example, we will show how information regarding the relative production efficiency of individual management measures can be used to guide the formulation of cost effective plans. In this approach, we estimate the cost and output associated with each management measure under consideration and rank the measures in order of their production efficiency. We then formulate plans by adding measures in order of their production efficiency ranking. This process results in the derivation of a range of cost effective plans. In so doing, we circumvent the need for cost effectiveness analysis to screen out non-cost effective plans. We will also step through an incremental cost analysis of the plans that are formulated in this process.

We caution users of this manual that the ability to use the relative production efficiency of management measures to guide plan formulation, in many cases will be dependent on the assumption that the costs and outputs of those management measures are additive. Where the “additive assumption” does not hold, other approaches to plan formulation should be applied.

This example is based on a recent examination of the feasibility of restoring a series of wetland sites in an urban region. Specifically, the Corps was asked to “describe and assess each site based upon existing available information; develop preliminary solutions for wetland restoration; identify potential environmental outputs; develop reconnaissance level cost estimates; and identify any impediments to project implementation.” Five sites were proposed for evaluation; we will refer to these as: Site A, Site B, Site C, Site D, and Site E.

Each site provides like outputs (a particular type of wetland habitat) measured in like units (habitat units). We will assume that all costs and outputs are additive across sites. Also, instead of listing a range of alternative plans, we only have information for one selected alternative at each site. An assumption is made that someone has already identified the “best” plan at each site. Thus, we can think of this analysis as a *programmatic* analysis where we are identifying the order in which to implement sites. This order is determined by production efficiency.

Plan Formulation

In this example, we will consider the restoration of each individual site as a management measure. Each management measure is both independent and combinable; that is, we could implement any site alone, or in combination with any other site(s). Thus, each site could stand alone as a plan, or be combined with other sites in any order to form other plans. Because we are assuming that the cost and output estimates of management measures are additive, all measures are combinable, and we are only considering one scale of each measure, we can use the relative production efficiency of each of the management measures to guide us in combining the measures into cost effective plans.

Since all sites are independent, all combinations are possible, and costs and outputs are assumed additive, it makes sense that we should implement the management measure (site) that is the "best deal" (that is, most efficient in production) first as a stand alone plan, and formulate each successive plan by adding the successively "next-best" management measure (site). How then do we determine which management measure is the "best deal"?

Such determinations are based upon the cost and output estimates for each management measure. Estimating the cost and output associated with individual measures requires that such estimations be made as if each measure were to "stand alone". If these estimates are no longer accurate when measures are combined with others due to the existence of non-additive cost or output relationships, the "add the next-best measure"decision rule for plan formulation falls short. This is the rationale for requiring that cost and output estimates be additive if the production efficiency approach is to be used for plan formulation.

In our example, a modified version of a Habitat Evaluation Procedure analysis was used to identify environmental outputs in habitat units (HUs) for restoration alternatives at each site. Reconnaissance level cost estimates were prepared for restoring each alternative site. The results of the output estimates and the cost estimates for each management measure are included in Table 3-2.

From Table 3-2, it is possible to make some inferences about the relative production efficiencies of different management measures. For example, it is clear that Site C, at which we can produce 462 habitat units for $19 million, is a better deal (or is more efficient in production) than Site D, at which we can only produce 408 habitat units at a higher cost of $62 million. Site A provides 48 more habitat units than Site D for $41.5 million less.

Table 3-2 Output and Cost of Management Measures		
MANAGEMENT MEASURE:	COST: ($ X 1,000,000)	OUTPUT: (HUs)
Restore Site A	$20.5	456
Restore Site B	$91.5	1845
Restore Site C	$19.0	462
Site Restore D	$62.0	408
Restore Site E	$ 4.5	60

We can make the comparison of *production efficiencies* across management measures more apparent by applying the concept of average cost to our data. By calculating the cost of production on an *average cost per unit* basis for each management measure, we make the relative production efficiency of each management measure more apparent. Table 3-3 supplements Table 3-2 with a column for Average Cost For Each Management Measure.

Table 3-3 Output, Cost and Average Cost for Each Management Measure			
MANAGEMENT MEASURE:	COST: ($ X MILLION)	OUTPUT: (HUs)	AVERAGE COST FOR EACH MANAGEMENT MEASURE: ($/HU)
Restore Site A	20.5	456	44,956
Restore Site B	91.5	1845	49,593
Restore Site C	19.0	462	41,125
Restore Site D	62.0	408	151,960
Restore Site E	4.5	60	75,000

Now, by scanning the last column in Table 3-3, we can easily rank the management measures by their production efficiencies. For example, Site C is the “best deal”; it is the most efficient in production, producing habitat units at the lowest unit cost, $41,125 each. Site A ranks second, followed by Sites B, E, and D, respectively. We can now reorder the management measures by their production efficiencies. The reordered measures comprise Table 3-4.

Table 3-4 Output, Cost and Average Cost of Each Management Measure Ranked by Production Efficiency

MANAGEMENT MEASURE:	COST: ($ X MILLION)	OUTPUT: (HUs)	AVERAGE COST FOR EACH MANAGEMENT MEASURE: ($/HU)
Restore Site C	19.0	462	41,125
Restore Site A	20.5	456	44,956
Restore Site B	91.5	1845	49,593
Restore Site E	4.5	60	75,000
Restore Site D	62.0	408	151,960

The data found in Table 3-4 can be used to guide the formulation of a range of cost effective plans. Because each management measure is producing the same type of output, all other considerations aside, we would implement the management measure which is the "best deal" (most efficient in production) first. Since the best deal is Site C, we will want to implement it first. Thus, the first alternative plan under consideration would be "Restore Site C". To form the next plan, we would add to the first plan the management measure with the lowest average cost of those remaining. Each successive plan will add, to the last plan, the management measure with the lowest average cost of those remaining. Through this process, we are using the production efficiency of management measures as a basis for formulating alternative plans. The range of cost effective alternative plans that is generated using this technique is included in Table 3-5.

It is possible that we might have two or more different management measures that produce the same output for the same cost. In such instances, all other considerations aside (that is, we are concerned only with cost and output and we have equal confidence in the cost and output estimates for each such measure), we would be indifferent as to which management measure we would implement first, but would implement each such management measure before any other management measure with a higher cost per unit. Similarly, it is possible that we might have two or more different management measures that produce different cost and output levels but that each have the same average cost. Again, based only upon production efficiency, we would be indifferent as to the order in which we would implement measures. In the previous case, where we had two or more measures with the same cost and output, we said that we would be indifferent as long as we were only concerned with cost and output, and we placed equal confidence in our cost and output estimates for each such measure. In this case however, our decision might also be affected by other considerations such as minimum or maximum output thresholds, or by cost constraints.

Table 3-5 Alternative Plans with Incremental Cost Per Unit

PLAN:	COST: ($ X MILLION)	OUTPUT: (HUs)	AVERAGE COST: ($/HU)	INCREMENTAL COST: ($ X MILLION)	INCREMENTAL OUTPUT: (HUs)	INCREMENTAL COST PER UNIT: ($/HU)
No-Action Plan	0.0	0	not applicable	not applicable	not applicable	not applicable
Site C	19.0	462	41,125	19.0	462	41,125
Site C +Site A	39.5	918	43,028	20.5	456	44,956
Site C +Site A+ Site B	131.0	2763	47,412	91.5	1845	49,593
Site C +Site A + Site B + Site E	135.5	2823	47,999	4.5	60	75,000
Site C +Site A + Site B + Site E + Site D	197.5	3231	61,127	62.0	408	151,960

Incremental Cost Analysis

The information contained in Table 3-5 can be used to conduct an incremental cost analysis. To do so, we will first evaluate the least expensive plan, "Site C". We see we can get 462 additional habitat units for an additional cost of $19 million ($41,125 per unit) if we implement "Site C" instead of the "No-Action Plan". If we decide that Site C is worth it, then we will evaluate whether the 456 additional habitat units provided by implementing "Site C + Site A" instead of "Site C" is worth its additional cost $20.5 million (44,956 per unit). This iterative process will continue until it is determined that the additional cost of adding another management measure, in this case "Site", is not worth the additional output it provides.

Of special interest in Table 3-5 is the divergence in values for "Incremental Cost Per Unit" and "Average Cost". This example demonstrates the potential for misinformed and improper decision making when basing scale selection choices on *average,* instead of *incremental*, cost information. The rationale for requiring incremental cost analysis is to *expose* the variation in cost from one plan to another. Average costs tend to *obscure* the variation in cost across plans. For example, look at the final plan, "Site C + Site A + Site B + Site E + Site D". The average cost of this plan is $61,127 per habitat unit. However, this average cost information does not show that the plan provides 408 habitat units over the plan prior to it, "Site C + Site A + Site B + Site E", and that those additional 408 habitat units cost $151,960 each; over a 100% increase in unit cost from the previous plan.

Creating a graph of the incremental cost information in Table 3-5, can make the relationship of cost and output for each alternative, as well as the *variation* in cost and output across alternatives, more visually apparent. Figure 3-3 contains such a graph. Each "box" within the graph represents the incremental cost and incremental output associated with the respective plan.

Because the graph's vertical axis measures incremental cost per unit, the height of each box represents the corresponding plan's additional cost per unit over the cost of the last plan under consideration. For example, the height of the first box (C) shows that the additional output provided by implementing restoration at Site C, as opposed to no action, will cost approximately $41,000 per habitat unit. Here, we say "approximately" because the axes on our graph do not show precision down to the exact unit. The important information to be obtained from the graph is not the precise values, but rather the relative relationships of the additional output provided by plans - the additional unit cost of that output, and the variation in unit cost of additional output across plans.

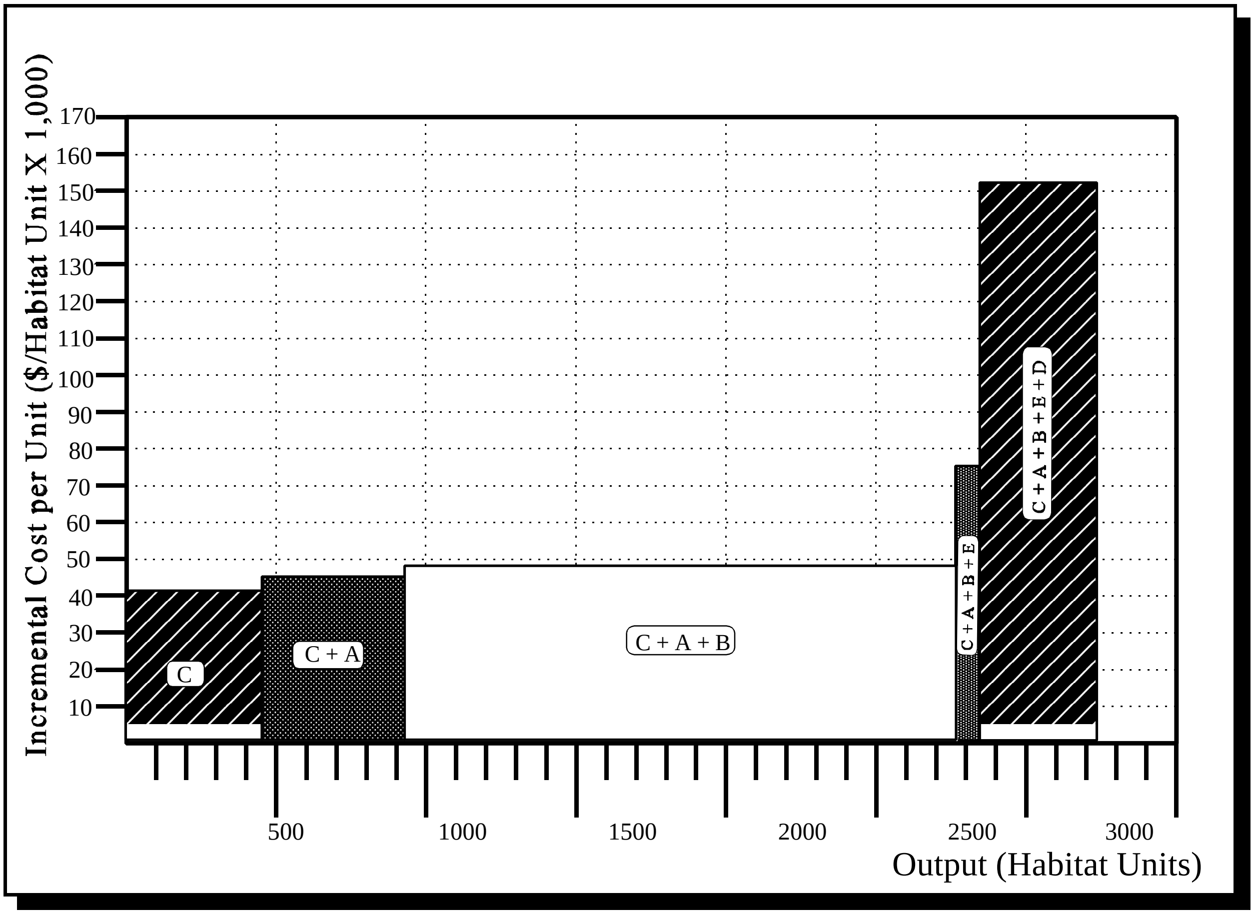


Figure 3-3 Incremental Cost Graph

The horizontal axis of the graph measures output. Thus, the width of each plan's box represents the additional output provided by that plan over the output of the plan preceding it. To continue with our example, the width of the first box (C) shows that implementing restoration at Site C, as opposed to no action, will provide approximately 460 habitat units.

Since the height of each box represents the *cost per unit* of the incremental (additional) output provided by the plan, and the width of each box represents the incremental (additional) *units of output* provided by the plan; it follows that the area of each box represents the incremental (additional) cost of the plan. In our example, the height ($41,000 per habitat unit) multiplied by the width (460 habitat units) approximates the incremental cost of plan “Site C” ($18.9 million).

Now let's look at the next plan “Site C + Site A”. The height of this box approximates the additional cost per unit that will be incurred by implementing this plan instead of the prior plan “Site C” ($45,000 per habitat unit). The width of the box approximates the additional output provided (455 habitat units). The area of the box approximates the incremental cost of the decision to implement “Site C + Site A” instead of “Site C” ($20.5 million).

If we measure along the horizontal axis from the origin to the end point of the “C + A” box, this end point approximates the total output provided by plan “Site C + Site A” (approximately 920 habitat units). Also, if we add the areas of the boxes for plan “Site C” and plan “Site C + Site A”, which both represent the incremental cost of those plans respectively, the result will approximate the total cost of plan “Site C + Site A” ($39.4 million).

Again, the intent of the graph is not for analysts and decision makers to make precise measurements and compute areas; the information that would result from such measurements and calculations is already available in Table 3-5. The intent of the graph is to visually communicate the relative relationships of cost and output in and across alternative plans. It is useful, however, to know what the box heights, widths and areas represent if this information is to be used to support decision making.

Let's turn our discussion to the types of information which can be gained from examination of the incremental cost graph in Figure 3-3. Examining Figure 3-3, we see that there is a relatively small increase in incremental cost per unit across plans “C”, “C + A” and “C + A + B”; while the increase in habitat units produced across this interval is relatively large. Conversely, as we compare “C + A + B” to “C + A + B +E” we witness a relatively large increase in incremental cost per unit, and a relatively small increase in habitat units. This is also the case as we compare “C + A + B + E” to “C + A + B + E + D”.

Such points, where we see large variations in cost should trigger examination of “what is going on here” and “is it worth it to continue production?” However, there is no absolute rule that large jumps in cost levels signify points where production should cease. Rather, incremental cost analysis should look at each individual increment and evaluate its worth based upon its additional output and cost. The question for each successive increment of output should be “is this additional output worth its additional cost?”

In the actual study from which this example was drawn, decision makers found the output provided by plan “C + A + B” to be the largest scale plan worth its cost. The additional output provided by either of the two larger scale plans was judged to be too costly. The level of output which is determined to be worth producing is dependent on the planning setting. For instance, had we been evaluating habitat units for an abundant species such as field rabbits, we might have found that the cost of the best deal, Site C, was too high for rabbit habitat. Similarly, if we had been evaluating habitat for an endangered species, we might have found it “worth it” to restore out to Site D. These decisions of how much to produce are based upon the judgment of decision makers. Incremental analysis provides information to assist decision makers in making such choices.

The above example involved the evaluation of a set of independent sites where we were given a single alternative at each site and cost and output estimates of individual sites were assumed to be additive. While this may appear simplistic, there are ongoing examples of the appropriate application of this type of analysis. For example, projects proposed for implementation within the authorization of the Coastal Wetlands Planning, Protection and Restoration Act (sometimes called the "Breaux Bill") go through a similar process of evaluation. The environmental effects of all projects are estimated using the same indicators and units of measurement. A recommended plan is identified at each proposed project; all project proposals are then listed with their respective costs and outputs and are ranked by average cost. With some exceptions for other evaluative criteria, projects are implemented in order of increasing average cost until budget constraints are reached.

This "relative production efficiency" approach to plan formulation may be best suited for determining the order in which different restoration sites should be implemented at the programmatic level. It requires that each site produces the same environmental output measured in the same units as other sites within the program. The limiting assumption that cost and output estimates of different measures are additive may be, in some cases, more acceptable at the programmatic level than at the individual site level. This approach will provide us with a list of plans such that the first plan is the most efficient in production (provides output at the lowest cost per unit), and then, each successive plan is the next-most-efficient in production (provides additional output at the lowest additional cost per unit) at the programmatic level.

An assumption of this production efficiency approach is that the best plan has already been selected at each site. Because of other limiting assumptions of this approach (for example, additive costs and outputs, independent and combinable management measures) it may not be best suited to plan formulation and evaluation at the site level. In addition, while the production efficiency approach is useful for identifying a range of cost effective alternative plans in some situations, it will not always identify all possible cost effective plans that could be formulated given the management measures under consideration. This unidentified information could result in the selection of a less desirable plan than would have been chosen had the information been available.

For example, consider a planning setting where we have either a budget constraint or a specific output target in mind. Because the production efficiency approach identifies some, but not necessarily all, possible cost effective plans for a given set of measures, there may exist a cost effective plan which would land us closer to our constraint or target but which was not identified in our approach to plan formulation. Situations may also arise where analysts are faced with uncertainty as to the reliability of cost and/or output estimates. In such situations, it may be desirable to look at a broader range of plans with additional levels of cost and output.

DERIVE ALL POSSIBLE COMBINATIONS OF MANAGEMENT MEASURES APPROACH TO PLAN FORMULATION

This "derive all combinations of management measures" approach to plan formulation and evaluation, is a slightly modified version of the plan formulation and evaluation methodology presented in *Cost Effectiveness*

Analysis for Environmental Planning: Nine EASY Steps (Orth 1994) . While typically requiring additional analytical effort, this nine step approach can have several advantages over the "relative production efficiency of management measures" approach presented in the previous section.

Some advantages of this nine step approach include: it is not limited by requiring the assumption of additive cost and output estimates; it can handle non-combinable and/or dependent measures as well as measures with multiple scales. An additional and important advantage of this approach is that it can provide an expanded level of *information* about the relationships among possible solutions. Specifically, given a fixed set of management measures, this approach provides information regarding the relationship of cost and output for all possible plans, identification of the least cost plan for every possible level of output, and the identification of the complete range of cost effective plans. Another important advantage of this approach is its educational value. By working through each step of this approach, practitioners can gain insight into the potential information to be gained by this process and the rationale for cost effectiveness and incremental cost analysis in environmental restoration planning.

This presentation of the analytical procedures in the *Nine EASY Steps* process has been modified slightly from its original form in *Cost Effectiveness Analysis for Environmental Planning: 9 EASY Steps* to make the discussion of the process consistent with terminology presented thus far in this manual. We will summarize the nine steps as follows:

Plan Formulation Steps:

- **1**. Display Outputs and Costs of Management Measures
- **2**. Identify Management Measure Relationships
- **3**. Add Costs and Outputs of Combinations

Cost Effectiveness Analysis Steps

- **4**. Identify "Production Inefficient" Solutions
- **5**. Identify "Production Ineffective" Solutions

Incremental Cost Analysis Steps

- **6**. Calculate and Display Incremental Costs

Additional Analytical Steps to Assist in Scale Selection

- **7**. Calculate Change in Unit Cost from No-Action Plan to All Other Plans
- **8**. Recalculate Change in Unit Cost from Last Selected Plan
- **9**. Tabulate and Display Incremental Costs of Selected Plans

Steps One, Two and Three are primarily concerned with plan formulation, specifically with generating all possible alternative plans from the management measures under consideration. Steps Four and Five are primarily for cost effectiveness analysis of alternative plans. At this point we can provide a graph of those plans that were not screened out in the prior two steps; this graph can be thought of as the cost effectiveness frontier. This graph plots the cost and output associated with all cost effective plans. Step Six calculates and displays the incremental cost incurred and incremental output provided as project scale is increased by advancing through the cost effective plans identified in Step Five.

The information provided by Step Six is intended to support the selection of the appropriate project scale. Sometimes the results of Step Six are difficult to interpret because of fluctuations in incremental cost per unit as we increase project scale. Such fluctuations in incremental unit cost often result when major equipment, mobilization, or other such costs must be incurred to reach a higher level of output and are followed by relatively low incremental unit costs for one or more subsequent output levels which are taking advantage of the previously incurred costs. The resulting incremental cost graph has been described as "lumpy", referring to these fluctuations. Steps Seven through Nine will "smooth out" such "lumpy" incremental cost graphs, further illuminating rises in incremental unit costs and facilitating the selection of appropriate project scale.

The "smoothing" procedure outlined in Steps Seven through Nine is based upon an arbitrary, but informed, decision rule whereby we identify those plans which are most efficient in production as project scale is increased. The authors acknowledge that other criteria could be applied in smoothing the curve, but that doing so based upon production efficiency is, in our opinion, a rational approach resulting in the identification of a range of plans where we are continually getting the "next-best-deal" as we increase project scale.

Step Seven calculates the incremental cost per unit of implementing each plan instead of the no action plan, selecting the plan with the lowest incremental cost per unit and deleting all plans that produce lower output levels. Step Eight involves the iterative analytical procedure of recalculating the incremental cost per unit of selecting each remaining plan instead of the last selected plan, and again selecting the plan with the lowest incremental cost per unit and deleting all plans that produce a lower output level. This procedure is reiterated until the last remaining plan is selected. Step Nine tabulates and displays the incremental cost and incremental output of the plans identified in steps seven and eight. The resultant information may illuminate jumps in unit cost as project scale increases facilitating plan selection.

For this demonstration of the application of the *Nine EASY Steps* procedure, we will add two additional layers of complexity to our wetlands site evaluation example used thus far throughout the Chapter. The addition of the hypothetical data is to display features and capabilities of the *Nine EASY Steps* methodology; for example, its usefulness in both "site" and "programmatic" planning.

We will continue with our evaluation of the five management measures; Restore Site A, Restore Site B, Restore Site C, Restore Site D, and Restore Site E. However, now we will also be considering four scales of restoration at Site B and two alternative restoration plans at Site D. The four scales at Site B apply the same management measures but to increasing acreage. Because implementing any one scale precludes the implementation of any other scale, these four scales are mutually exclusive. However, each of the scales can be combined with any other management measure(s). The costs and outputs of the four scales at Site B are included in Table 3-6. Also, at Site D we will add a hypothetical alternative for wetlands restoration. The result is two mutually exclusive plans at Site D; one utilizing open channels, the other utilizing closed culverts. Because the two plans at Site D are mutually exclusive, we can treat them as scales of the managment measure Restore Site D. The costs and the outputs for the two plans at Site D are included in Table 3-7.

The following example is organized by the "Steps" in the *Nine EASY Steps* procedures. Each step will include both general instructions and a specific application to our wetlands site evaluation problem. Any tables and charts created within each step will be called "Exhibits". For example, the Table found in the description of Step One is called Exhibit Step 1.

Table 3-6 Cost and Output of Alternative Project Scales at Site B

SCALE:	DESCRIPTION:	COST:	OUTPUT:
B1	Acquire & Restore 200 Acres.	$7,080,000	78 habitat units
B2	Acquire & Restore 400 Acres.	$8,848,359	117 habitat units
B3	Acquire & Restore 600 Acres.	$22,102,000	514 habitat units
B4	Acquire & Restore 800 Acres.	$91,500,000	1845 habitat units

Table 3-7 Cost and Output of Alternative Scales at Site D

SCALE:	DESCRIPTION:	COST:	OUTPUT:
D_1	2 tide gates + 4 closed culverts	$62,000,000	408 HUs
D_2	2 tide gates + 2 open channels	$80,000,000	435 HUs

Step One - Display Outputs and Costs of Management Measures

Display the environmental output and cost estimates of the various management measures and, where applicable, different scales of particular management measures. Outputs and costs can be displayed as average annual ("annualized") outputs and costs or total outputs and costs; either is acceptable so long as they are comparable. Exhibit Step 1 displays this information in a table format.

MANAGEMENT MEASURE:	SCALES:	COST:	OUTPUT:
NO ACTION	N.A.	$0	0
RESTORE SITE A	N.A.	$20,500,000	456
RESTORE SITE B	1(200 ACRES)	$7,800,000	78
	2(400 ACRES)	$8,848,359	117

	3(600 ACRES)	$22,102,000	514
	4(800 ACRES)	$91,500,000	1845
RESTORE SITE C	N.A.	$19,000,000	462
RESOTRE SITE D	1(WITH CULVERTS)	$62,000,000	408
	2(WITH CHANNELS)	$80,000,000	435
RESTORE SITE E	N.A.	$4,500,000	60

EXHIBIT STEP 1 COST AND OUTPUT OF MANAGEMENT MEASURES

Step 2 - Identify Management Measure Relationships

In this step, we identify all *combinability* and *dependency* relationships as defined earlier in this chapter. This process involves analysis of the management measures to identify those that cannot be implemented together and those that can be implemented together (combinability) as well as those measures which may only be implemented after the implementation of specific other measures (dependency).

In our example, we had specified that the two alternatives at Site D were mutually exclusive. While they may not be combined with one another, they each can be combined with all other combinable management actions. As defined in *Nine EASY Steps*, the "scales" of any management action are not combinable with one another. For this reason, we can treat the two different, but mutually exclusive, alternatives at Site D as different scales of the management measure "Restore Site D". We could also have treated those two alternatives as different management measures, for example "Restore Site D_A" and "Restore Site D_B " and then not allowed combinations of the two.

Similar to Site D, Site B also has more than one option (scale). The four scales for Site B are more typical of "scaling" than are the two options at Site D. At Site B we are applying the same management measures but to increasing areas of land. Therefore the different scales of restoration at Site B are not combinable with one another, but are each combinable with any of the other management measures. Exhibit Step 2A contains a matrix showing the combinability of management actions.

	Site A	**Site B**	**Site C**	**Site D**	**Site E**
Site A	-	YES	YES	YES	YES
Site B	-	-	YES	YES	YES
Site C	-	-	-	YES	YES
Site D	-	-	-	-	YES

Site E	-	-	-	-	-

EXHIBIT STEP 2A MATRIX IDENTIFYING COMBINABLE MANAGEMENT MEASURES

A similar matrix can be used to tabulate dependency path relationships. In such a dependency path matrix, across each row corresponding to a management measure, checks can be placed in each cell where there is a dependency upon the measure corresponding to the respective column. Since there are no dependency relationships in our current example, let's return to the dependency path diagram in Figure 3-1 to demonstrate a dependency path matrix. The dependency path diagram in Figure 3-1 shows that measures A and D are independent; B is dependent on A; C is dependent on both A and B; and E is dependent on D (note that the management measures A-E in Figure 3-1 do not correspond to Sites A-E in our current example). Arrows have been placed in the cells across each row (corresponding to each measure) in the matrix wherever that measure is dependent upon the measure in the corresponding column. For example, look across the row for measure C. Arrows indicate that measure C is dependent upon both measures A and B.

	Measure A	Measure B	Measure C	Measure D	Measure E
Measure A	-	-	-	-	-
Measure B	↑	-	-	-	-
Measure C	↑	↑	-	-	-
Measure D	-	-	-	-	-
Measure E	-	-	-	↑	-

EXHIBIT STEP 2B MATRIX IDENTIFYING DEPENDENT MANAGEMENT MEASURES

The purpose of identifying the combinability and dependency relationships of management measures is to assist in identifying all viable combinations of measures in Step 3**.**

Step 3 - Derive Combinations and Calculate Costs and Outputs

Identify all possible combinations of the management measures' scales, and calculate the output and cost of each combination. These combinations are the alternative plans that can be considered. When all management measures are combinable, the number of all possible combinations (plans) can be computed by the formula in

Figure 3-4 . In our example, this formula will tell us that we can come up with 120 possible combinations. For Site A, there is one management measure scale. For Site B, there are four scales. For Site C there is one scale. For Site D, we have two scales. Site E has one scale. For each management measure, there is always a "no-action" scale. This no-action scale is accounted for in the formula found in Figure 3-4 by adding 1 to each count of management measure scales, (e.g., $i_a + 1$, $I_b + 1$) Therefore, the number of possible combinations in our example are computed by multiplying (2) X (5) X (2) X (3) X (2); which equals 120.

$Y=(i_A + 1)x(i_B + 1)...x...(i_N + 1)$

Where:

Y = number of combinations (including "no action");

A,B,...,N = management measures A, B, etc. through the last measure N; and

i_A = number of scales for management measure A.

Figure 3-4 Formula for Number of Combinations

When using this approach to plan formulation, reason must be used in selecting the number of management measures and their respective scales. The potential exists for the number of possible combinations to quickly grow to an unmanageable number. For example, consider a case where we have 10 different management measures, each of which have 9 action scales and 1 no-action scale. The resultant number of combinations is: (10 X 10 X 10 X 10 X 10 X 10 X 10 X 10 X 10 X 10) = 10^{10} = 10,000,000,000; ten billion alternative plans! While the automated procedures accompanying this manual greatly reduce the effort required for the derivation of large numbers of combinations, it is still important to use reason regarding the level of data to be entered into the program.

There are methods to reduce such a large range of combinations to a more manageable number. For example, cost effectiveness analysis can be conducted within the scales of each measure prior to combining measures into plans. Thus, non-cost effective scales can be eliminated from inclusion in combinations. Scales for each management measure can also be limited, for example, to "high", "medium and "most likely" sizes based upon professional judgment. Similarly, scales may be limited by certain practicalities or realities of the planning setting at hand (for example, pumps may exist in only one size or the site may set physical limits on sizes).

Exhibit Step 3A tabulates the possible combinations (plans) and their added costs and outputs. We have assumed that the costs and outputs of management actions are additive. While addition has been used here, the combined totals may not always be calculated as simple sums, but rather should be estimated using the applicable procedure. In this example, this would mean recalculating outputs for combinations of management measures using the same habitat model that was initially used to calculate outputs for each individual management action. Similarly cost estimates would be recalculated for each alternative plan (combination of management measures) as a whole.

EXHIBIT STEP 3A: OUTPUT AND COST OF ALL COMBINATIONS OF MANAGEMENT MEASURES (PLANS)

PLAN:					OUTPUT: (HUs)	COST: ($)	PLAN:					OUTPUT: (HUs)	COST: ($)
A0	B0	C0	D0	E0	0	0	A0	B0	C0	D1	E0	408	62,000,000
A0	B1	C0	D0	E0	78	7,800,000	A0	B1	C0	D1	E0	486	69,800,000
A0	B2	C0	D0	E0	117	8,848,359	A0	B2	C0	D1	E0	525	70,848,359
A0	B3	C0	D0	E0	514	22,102,000	A0	B3	C0	D1	E0	922	84,102,000
A0	B4	C0	D0	E0	1,845	91,500,000	A0	B4	C0	D1	E0	2,253	153,500,000
A1	B0	C0	D0	E0	456	20,500,000	A1	B0	C0	D1	E0	864	82,500,000
A1	B1	C0	D0	E0	534	28,300,000	A1	B1	C0	D1	E0	942	90,300,000
A1	B2	C0	D0	E0	573	29,348,359	A1	B2	C0	D1	E0	981	91,348,359
A1	B3	C0	D0	E0	970	42,602,000	A1	B3	C0	D1	E0	1,378	104,602,000
A1	B4	C0	D0	E0	2,301	112,000,000	A1	B4	C0	D1	E0	2,709	174,000,000
A0	B0	C1	D0	E0	462	19,000,000	A0	B0	C1	D1	E0	870	81,000,000
A0	B1	C1	D0	E0	540	26,800,000	A0	B1	C1	D1	E0	948	88,800,000
A0	B2	C1	D0	E0	579	27,848,359	A0	B2	C1	D1	E0	987	89,848,359
A0	B3	C1	D0	E0	976	41,102,000	A0	B3	C1	D1	E0	1,384	103,102,000
A0	B4	C1	D0	E0	2,307	110,500,000	A0	B4	C1	D1	E0	2,715	172,500,000
A1	B0	C1	D0	E0	918	39,500,000	A1	B0	C1	D1	E0	1,326	101,500,000
A1	B1	C1	D0	E0	996	29,348,359	A1	B1	C1	D1	E0	1,404	109,300,000
A1	B2	C1	D0	E0	1,035	48,348,359	A1	B2	C1	D1	E0	1,443	110,348,359
A1	B3	C1	D0	E0	1,432	61,602,000	A1	B3	C1	D1	E0	1,840	123,602,000
A1	B4	C1	D0	E0	2,763	131,000,000	A1	B4	C1	D1	E0	3,171	193,000,000
A0	B0	C0	D0	E1	60	4,500,000	A0	B0	C0	D1	E1	468	66,500,000
A0	B1	C0	D0	E1	138	12,300,000	A0	B1	C0	D1	E1	546	74,300,000
A0	B2	C0	D0	E1	177	13,348,359	A0	B2	C0	D1	E1	585	75,348,359
A0	B3	C0	D0	E1	574	26,602,000	A0	B3	C0	D1	E1	982	88,602,000
A0	B4	C0	D0	E1	1,905	96,000,000	A0	B4	C0	D1	E1	2,313	158,000,000
A1	B0	C0	D0	E1	516	25,000,000	A1	B0	C0	D1	E1	924	87,000,000
A1	B1	C0	D0	E1	594	32,800,000	A1	B1	C0	D1	E1	1,002	94,800,000
A1	B2	C0	D0	E1	633	33,848,359	A1	B2	C0	D1	E1	1,041	95,848,359
A1	B3	C0	D0	E1	970	47,102,000	A1	B3	C0	D1	E1	1,438	109,102,000
A1	B4	C0	D0	E1	2,361	116,500,000	A1	B4	C0	D1	E1	2,769	178,500,000
A0	B0	C1	D0	E1	522	23,500,000	A0	B0	C1	D1	E1	930	85,500,000
A0	B1	C1	D0	E1	600	31,300,000	A0	B1	C1	D1	E1	1,008	93,300,000
A0	B2	C1	D0	E1	639	32,348,359	A0	B2	C1	D1	E1	1,047	94,348,359
A0	B3	C1	D0	E1	1,036	45,602,000	A0	B3	C1	D1	E1	1,444	107,602,000
A0	B4	C1	D0	E1	2,367	115,000,000	A0	B4	C1	D1	E1	2,775	177,000,000

Exhibit Step 3A is continued on next page.

A1	B0	C1	D0	E1	978	44,000,000	A1	B0	C1	D1	E1	1,386	106,000,000

PLAN:					OUTPUT: (HUs)	COST: ($)		PLAN:					OUTPUT: (HUs)	COST: ($)
A1	B1	C1	D0	E1	1,056	51,800,000		A1	B1	C1	D1	E1	1,464	113,800,000
A1	B2	C1	D0	E1	1,095	52,848,359		A1	B2	C1	D1	E1	1,503	114,848,359
A1	B3	C1	D0	E1	1,492	66,102,000		A1	B3	C1	D1	E1	1,900	128,102,000
A1	B4	C1	D0	E1	2,823	135,500,000		A1	B4	C1	D1	E1	3,231	197,500,000
A0	B0	C0	D2	E0	435	80,000,000		A0	B0	C0	D2	E1	495	84,500,000
A0	B1	C0	D2	E0	513	87,800,000		A0	B1	C0	D2	E1	573	92,300,000
A0	B2	C0	D2	E0	552	88,848,359		A0	B2	C0	D2	E1	612	93,348,359
A0	B3	C0	D2	E0	949	102,102,000		A0	B3	C0	D2	E1	1,009	106,602,000
A0	B4	C0	D2	E0	2,280	171,500,000		A0	B4	C0	D2	E1	2,340	176,000,000
A1	B0	C0	D2	E0	891	100,500,000		A1	B0	C0	D2	E1	951	105,000,000
A1	B1	C0	D2	E0	969	108,300,000		A1	B1	C0	D2	E1	1,029	112,800,000
A1	B2	C0	D2	E0	1,008	109,348,359		A1	B2	C0	D2	E1	1,068	113,848,359
A1	B3	C0	D2	E0	1,405	122,602,000		A1	B3	C0	D2	E1	1,465	127,102,000
A1	B4	C0	D2	E0	2,736	192,000,000		A1	B4	C0	D2	E1	2,796	196,500,000
A0	B0	C1	D2	E0	897	99,000,000		A0	B0	C1	D2	E1	957	103,500,000
A0	B1	C1	D2	E0	975	106,800,000		A0	B1	C1	D2	E1	1,035	111,300,000
A0	B2	C1	D2	E0	1,014	107,848,359		A0	B2	C1	D2	E1	1,074	112,348,359
A0	B3	C1	D2	E0	1,411	121,102,000		A0	B3	C1	D2	E1	1,471	125,602,000
A0	B4	C1	D2	E0	2,742	190,500,000		A0	B4	C1	D2	E1	2,802	195,000,000
A1	B0	C1	D2	E0	1,353	119,500,000		A1	B0	C1	D2	E1	1,413	124,000,000
A1	B1	C1	D2	E0	1,431	127,300,000		A1	B1	C1	D2	E1	1,491	131,800,000
A1	B2	C1	D2	E0	1,470	128,348,359		A1	B2	C1	D2	E1	1,530	132,848,359
A1	B3	C1	D2	E0	1,867	141,602,000		A1	B4	C1	D2	E0	3,198	211,000,000
A1	B3	C1	D1	E1	1,927	146,102,000		A1	B4	C1	D2	E1	3,258	215,500,000

In order to identify the management measures within each plan, we utilize the letters used to identify each site (A-E). Wherever a letter is followed by a 0, that indicates that there is no implementation of that management measure within the respective plan. Thus, the planning-area-wide no action plan is signified by A0+B0+C0+D0+E0. For Site B, which has five different scale options, (including no-action), each scale is signified by a suffix (0, 1, 2, 3, and 4). Similarly, for Site D, which has three different scales, (including no-action), each scale is signified by a suffix (0, 1 and 2). For the other sites, where there is only one scale other than no-action, a suffix of 1 signifies action at those sites and again, a suffix of 0 indicates that management measure is not implemented within that plan.

The cost and output associated with each plan found in Exhibit Step 3A can be plotted in a scatter chart. Such a graphical representation of the relationship between cost and output for all combinations is included as Exhibit Step 3B.

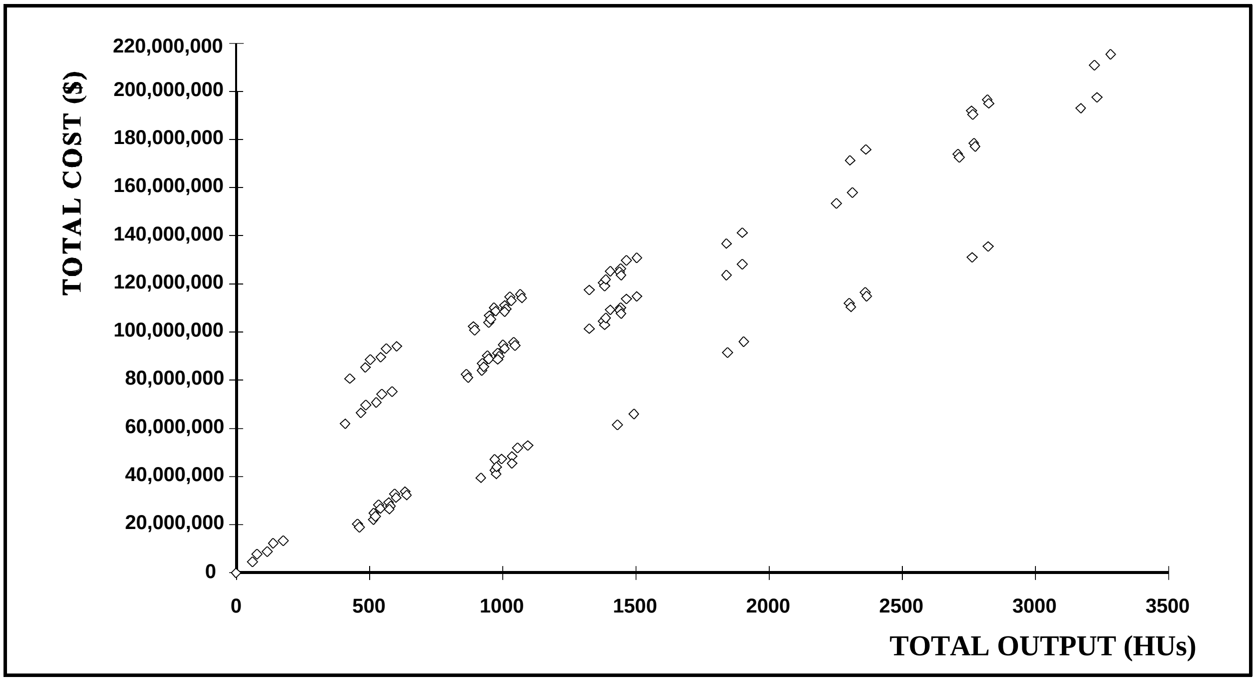


EXHIBIT STEP 3B TOTAL COST AND TOTAL OUTPUT OF ALL PLANS

If a planning study has management measures which aren't combinable with others, we can first derive all combinations, as if all management measures *were* combinable, and then go back and delete combinations which aren't viable. For example, if we were to alter the previous example such that “C” and “D” were not combinable, we could derive all combinations of all management measures to arrive at Exhibit Step 3A, and then scan through the table deleting combinations of B(>0) + C(>0). Similarly, if we are faced with management measures that are dependent upon other measures, we can derive all combinations and then go back and delete those combinations that do not meet dependency path requirements. The automated procedures accompanying this manual facilitate each of these processes.

Step 4 - Identify Plans that Are Inefficient in Production

While Steps One through Three were concerned with plan formulation, the remaining steps are concerned with plan evaluation; specifically with the evaluation tools of cost effectiveness and incremental cost analyses. If plans were formulated by methods other than those outlined in Steps One through Three, Steps Four through Nine can be applied to those plans to conduct cost effectiveness and incremental cost analyses. Steps Four and Five outline the procedures for cost effectiveness analysis, and Steps Six through Nine describe processes for conducting incremental cost analysis.

The purpose of Step Four is to identify those plans which are *inefficient in production.* Plans that are “inefficient in production” are defined here as those where the same output level can be provided at a lesser cost by another plan. In order to identify such inefficient plans, we can sort the plans by their output level. Wherever there are two or more plans providing the same output level, aside from any other considerations (for example, uncertainty as to the reliability of cost or output estimates), we should eliminate the more costly plans for achieving that output level. This step identifies the least-cost plan for every level of output under consideration.

In Exhibit 4, inefficient plans have been shaded and will be eliminated from future cost effectiveness and incremental cost analyses procedures. In our example, three plans ([A0+B1+C0+D2+E1]; [A0 + B1 +C1 + D2 + E1]; and [A1 + B2 + C0 + D2 + E0]), are economically inefficient in production.

EXHIBIT STEP 4: ALL PLANS SORTED BY OUTPUT AND COST (SHADING OVER INEFFICIENT PLANS)

PLAN:					OUTPUT: (HUs)	COST: ($)	PLAN:					OUTPUT: (HUs)	COST: ($)
A0	B0	C0	D0	E0	0	0	A1	B3	C0	D0	E1	1,030	47,102,000
A0	B0	C0	D0	E1	60	4,500,000	A1	B2	C1	D0	E0	1,035	48,348,359
A0	B1	C0	D0	E0	78	7,800,000	**A0**	**B1**	**C1**	**D2**	**E1**	**1,035**	**111,300,000**
A0	B2	C0	D0	E0	117	8,848,359	A0	B3	C1	D0	E1	1,036	45,602,000
A0	B1	C0	D0	E1	138	12,300,000	A1	B2	C0	D1	E1	1,041	95,848,359
A0	B2	C0	D0	E1	177	13,348,359	A0	B2	C1	D1	E1	1,047	94,348,359
A0	B0	C0	D1	E0	408	62,000,000	A1	B1	C1	D0	E1	1,056	51,800,000
A0	B0	C0	D2	E0	435	80,000,000	A1	B2	C0	D2	E1	1,068	113,848,359
A1	B0	C0	D0	E0	456	20,500,000	A0	B2	C1	D2	E1	1,074	112,348,359
A0	B0	C1	D0	E0	462	19,000,000	A1	B2	C1	D0	E1	1,095	52,848,359
A0	B0	C0	D1	E1	468	66,500,000	A1	B0	C1	D1	E0	1,326	101,500,000
A0	B1	C0	D1	E0	486	69,800,000	A1	B0	C1	D2	E0	1,353	119,500,000
A0	B0	C0	D2	E1	495	84,500,000	A1	B3	C0	D1	E0	1,378	104,602,000
A0	B1	C0	D2	E0	513	87,800,000	A0	B3	C1	D1	E0	1,384	103,102,000
A0	B3	C0	D0	E0	514	22,102,000	A1	B0	C1	D1	E1	1,386	106,000,000
A1	B0	C0	D0	E1	516	25,000,000	A1	B1	C1	D1	E0	1,404	109,300,000
A0	B0	C1	D0	E1	522	23,500,000	A1	B3	C0	D2	E0	1,405	122,602,000
A0	B2	C0	D1	E0	525	70,848,359	A0	B3	C1	D2	E0	1,411	121,102,000
A1	B1	C0	D0	E0	534	28,300,000	A1	B0	C1	D2	E1	1,413	124,000,000
A0	B1	C1	D0	E0	540	26,800,000	A1	B1	C1	D2	E0	1,431	127,300,000
A0	B1	C0	D1	E1	546	74,300,000	A1	B3	C1	D0	E0	1,432	61,602,000
A0	B2	C0	D2	E0	552	88,848,359	A1	B3	C0	D1	E1	1,438	109,102,000
A1	B2	C0	D0	E0	573	29,348,359	A1	B2	C1	D1	E0	1,443	110,348,359
A0	**B1**	**C0**	**D2**	**E1**	**573**	**92,300,000**	A0	B3	C1	D1	E1	1,444	107,602,000
A0	B3	C0	D0	E1	574	26,602,000	A1	B1	C1	D1	E1	1,464	113,800,000
Left Column of Exhibit 4 continued next page.							**Right column of Exhibit 4 continued next page.**						
A0	B2	C1	D0	E0	579	27,848,359	A1	B3	C0	D2	E1	1,465	127,102,000
A0	B2	C0	D1	E1	585	75,348,359	A1	B2	C1	D2	E0	1,470	128,348,359
A1	B1	C0	D0	E1	594	32,800,000	A0	B3	C1	D2	E1	1,471	125,602,000

PLAN:					OUTPUT: (HUs)	COST: ($)	PLAN:					OUTPUT: (HUs)	COST: ($)
A0	B1	C1	D0	E1	600	31,300,000	A1	B1	C1	D2	E1	1,491	131,800,000
A0	B2	C0	D2	E1	612	93,348,359	A1	B3	C1	D0	E1	1,492	66,102,000
A1	B2	C0	D0	E1	633	33,848,359	A1	B2	C1	D1	E1	1,503	114,848,359
A0	B2	C1	D0	E1	639	32,348,359	A1	B2	C1	D2	E1	1,530	132,848,359
A1	B0	C0	D1	E0	864	82,500,000	A1	B3	C1	D1	E0	1,840	123,602,000
A0	B0	C1	D1	E0	870	81,000,000	A0	B4	C0	D0	E0	1,845	91,500,000
A1	B0	C0	D2	E0	891	100,500,000	A1	B3	C1	D2	E0	1,867	141,602,000
A0	B0	C1	D2	E0	897	99,000,000	A1	B3	C1	D1	E1	1,900	128,102,000
A1	B0	C1	D0	E0	918	39,500,000	A0	B4	C0	D0	E1	1,905	96,000,000
A0	B3	C0	D1	E0	922	84,102,000	A1	B3	C1	D2	E1	1,927	146,102,000
A1	B0	C0	D1	E1	924	87,000,000	A0	B4	C0	D1	E0	2,253	153,500,000
A0	B0	C1	D1	E1	930	85,500,000	A0	B4	C0	D2	E0	2,280	171,500,000
A1	B1	C0	D1	E0	942	90,300,000	A1	B4	C0	D0	E0	2,301	112,000,000
A0	B1	C1	D1	E0	948	88,800,000	A0	B4	C1	D0	E0	2,307	110,500,000
A0	B3	C0	D2	E0	949	102,102,000	A0	B4	C0	D1	E1	2,313	158,000,000
A1	B0	C0	D2	E1	951	105,000,000	A0	B4	C0	D2	E1	2,340	176,000,000
A0	B0	C1	D2	E1	957	103,500,000	A1	B4	C0	D0	E1	2,361	116,500,000
A1	B1	C0	D2	E0	969	108,300,000	A0	B4	C1	D0	E1	2,367	115,000,000
A1	B3	C0	D0	E0	970	42,602,000	A1	B4	C0	D1	E0	2,709	174,000,000
A0	B1	C1	D2	E0	975	106,800,000	A0	B4	C1	D1	E0	2,715	172,500,000
A0	B3	C1	D0	E0	976	41,102,000	A1	B4	C0	D2	E0	2,736	192,000,000
A1	B0	C1	D0	E1	978	44,000,000	A0	B4	C1	D2	E0	2,742	190,500,000
A1	B2	C0	D1	E0	981	91,348,359	A1	B4	C1	D0	E0	2,763	131,000,000
A0	B3	C0	D1	E1	982	88,602,000	A1	B4	C0	D1	E1	2,769	178,500,000
A0	B2	C1	D1	E0	987	89,848,359	A0	B4	C1	D1	E1	2,775	177,000,000
A1	B1	C1	D0	E0	996	47,300,000	A1	B4	C0	D2	E1	2,796	196,500,000
A1	B1	C0	D1	E1	1,002	94,800,000	A0	B4	C1	D2	E1	2,802	195,000,000
A0	B1	C1	D1	E1	1,008	93,300,000	A1	B4	C1	D0	E1	2,823	135,500,000
A1	**B2**	**C0**	**D2**	**E0**	**1,008**	**109,348,359**	A1	B4	C1	D1	E0	3,171	193,000,000
A0	B3	C0	D2	E1	1,009	106,602,000	A1	B4	C1	D2	E0	3,198	211,000,000
A0	B2	C1	D2	E0	1,014	107,848,359	A1	B4	C1	D1	E1	3,231	197,500,000
A1	B1	C0	D2	E1	1,029	112,800,000	A1	B4	C1	D2	E1	3,258	215,500,000

It is possible that we could encounter two or more plans which each produce the same output level at the same cost. In such a circumstance, based only upon our cost and output estimates, we would be

indifferent as to which plan should be selected if that particular output level is desired. Each such plan would be considered efficient in production.

Step 5 - Identify Plans that Are Ineffective in Production

Plans that are "ineffective in production" are defined here as those where greater output can be produced at a lesser or equal cost. In order to identify such plans, conduct a pair-wise comparison of outputs and costs of plans that passed through the efficiency screening in Step Four. Identify and mark for deletion those plans that will produce less output at an equal or greater cost than subsequently ranked plans. Exhibit Step 5 contains a table of plans that passed the efficiency screening with shading of those that are ineffective in production. The non-shaded plans comprise the set of cost effective plans. A revised listing of these cost effective plans is included in Exhibit 5B. A graph of the cost effective plans is included as Exhibit Step 5C. We are now ready to conduct incremental cost analyses in Step Six.

EXHIBIT STEP 5A: LEAST COST PLANS SORTED BY OUTPUT AND COST (SHADING OVER INEFFECTIVE PLANS)

PLAN:					OUTPUT: (HUs)	COST: ($)	PLAN:					OUTPUT: (HUs)	COST: ($)
A0	B0	C0	D0	E0	0	0	**A1**	**B3**	**C0**	**D0**	**E1**	**1,030**	**47,102,000**
A0	B0	C0	D0	E1	60	4,500,000	**A1**	**B2**	**C1**	**D0**	**E0**	**1,035**	**48,348,359**
A0	B1	C0	D0	E0	78	7,800,000	A0	B1	C1	D2	E1	*inefficient*	
A0	B2	C0	D0	E0	117	8,848,359	A0	B3	C1	D0	E1	1,036	45,602,000
A0	B1	C0	D0	E1	138	12,300,000	**A1**	**B2**	**C0**	**D1**	**E1**	**1,041**	**95,848,359**
A0	B2	C0	D0	E1	177	13,348,359	**A0**	**B2**	**C1**	**D1**	**E1**	**1,047**	**94,348,359**
A0	**B0**	**C0**	**D1**	**E0**	**408**	**62,000,000**	A1	B1	C1	D0	E1	1,056	51,800,000
A0	**B0**	**C0**	**D2**	**E0**	**435**	**80,000,000**	**A1**	**B2**	**C0**	**D2**	**E1**	**1,068**	**113,848,359**
A1	**B0**	**C0**	**D0**	**E0**	**456**	**20,500,000**	**A0**	**B2**	**C1**	**D2**	**E1**	**1,074**	**112,348,359**
A0	B0	C1	D0	E0	462	19,000,000	A1	B2	C1	D0	E1	1,095	52,848,359
A0	**B0**	**C0**	**D1**	**E1**	**468**	**66,500,000**	**A1**	**B0**	**C1**	**D1**	**E0**	**1,326**	**101,500,000**
A0	**B1**	**C0**	**D1**	**E0**	**486**	**69,800,000**	**A1**	**B0**	**C1**	**D2**	**E0**	**1,353**	**119,500,000**
A0	**B0**	**C0**	**D2**	**E1**	**495**	**84,500,000**	**A1**	**B3**	**C0**	**D1**	**E0**	**1,378**	**104,602,000**
A0	**B1**	**C0**	**D2**	**E0**	**513**	**87,800,000**	**A0**	**B3**	**C1**	**D1**	**E0**	**1,384**	**103,102,000**
A0	B3	C0	D0	E0	514	22,102,000	**A1**	**B0**	**C1**	**D1**	**E1**	**1,386**	**106,000,000**
A1	**B0**	**C0**	**D0**	**E1**	**516**	**25,000,000**	**A1**	**B1**	**C1**	**D1**	**E0**	**1,404**	**109,300,000**
A0	B0	C1	D0	E1	522	23,500,000	**A1**	**B3**	**C0**	**D2**	**E0**	**1,405**	**122,602,000**
A0	**B2**	**C0**	**D1**	**E0**	**525**	**70,848,359**	**A0**	**B3**	**C1**	**D2**	**E0**	**1,411**	**121,102,000**
A1	**B1**	**C0**	**D0**	**E0**	**534**	**28,300,000**	**A1**	**B0**	**C1**	**D2**	**E1**	**1,413**	**124,000,000**
A0	**B1**	**C1**	**D0**	**E0**	**540**	**26,800,000**	**A1**	**B1**	**C1**	**D2**	**E0**	**1,431**	**127,300,000**
A0	**B1**	**C0**	**D1**	**E1**	**546**	**74,300,000**	A1	B3	C1	D0	E0	1,432	61,602,000
A0	**B2**	**C0**	**D2**	**E0**	**552**	**88,848,359**	**A1**	**B3**	**C0**	**D1**	**E1**	**1,438**	**109,102,000**
Left column of Exhibit 5A is continued next page							**Right column of Exhibit 5A is continued next page.**						
A1	**B2**	**C0**	**D0**	**E0**	**573**	**29,348,359**	**A1**	**B2**	**C1**	**D1**	**E0**	**1,443**	**110,348,359**
A0	B1	C0	D2	E1	*inefficient*		**A0**	**B3**	**C1**	**D1**	**E1**	**1,444**	**107,602,000**
A0	B3	C0	D0	E1	574	26,602,000	**A1**	**B1**	**C1**	**D1**	**E1**	**1,464**	**113,800,000**

PLAN:					OUTPUT: (HUs)	COST: ($)
A0	B2	C1	D0	E0	579	27,848,359
A0	**B2**	**C0**	**D1**	**E1**	**585**	**75,348,359**
A1	**B1**	**C0**	**D0**	**E1**	**594**	**32,800,000**
A0	B1	C1	D0	E1	600	31,300,000
A0	**B2**	**C0**	**D2**	**E1**	**612**	**93,348,359**
A1	**B2**	**C0**	**D0**	**E1**	**633**	**33,848,359**
A0	B2	C1	D0	E1	639	32,348,359
A1	**B0**	**C0**	**D1**	**E0**	**864**	**82,500,000**
A0	**B0**	**C1**	**D1**	**E0**	**870**	**81,000,000**
A1	**B0**	**C0**	**D2**	**E0**	**891**	**100,500,000**
A0	**B0**	**C1**	**D2**	**E0**	**897**	**99,000,000**
A1	B0	C1	D0	E0	918	39,500,000
A0	**B3**	**C0**	**D1**	**E0**	**922**	**84,102,000**
A1	**B0**	**C0**	**D1**	**E1**	**924**	**87,000,000**
A0	**B0**	**C1**	**D1**	**E1**	**930**	**85,500,000**
A1	**B1**	**C0**	**D1**	**E0**	**942**	**90,300,000**
A0	**B1**	**C1**	**D1**	**E0**	**948**	**88,800,000**
A0	**B3**	**C0**	**D2**	**E0**	**949**	**102,102,000**
A1	**B0**	**C0**	**D2**	**E1**	**951**	**105,000,000**
A0	**B0**	**C1**	**D2**	**E1**	**957**	**103,500,000**
A1	**B1**	**C0**	**D2**	**E0**	**969**	**108,300,000**
A1	**B3**	**C0**	**D0**	**E0**	**970**	**42,602,000**
A0	**B1**	**C1**	**D2**	**E0**	**975**	**106,800,000**
A0	B3	C1	D0	E0	976	41,102,000
A1	B0	C1	D0	E1	978	44,000,000
A1	**B2**	**C0**	**D1**	**E0**	**981**	**91,348,359**
A0	**B3**	**C0**	**D1**	**E1**	**982**	**88,602,000**
A0	**B2**	**C1**	**D1**	**E0**	**987**	**89,848,359**
A1	**B1**	**C1**	**D0**	**E0**	**996**	**47,300,000**
A1	**B1**	**C0**	**D1**	**E1**	**1,002**	**94,800,000**
A0	**B1**	**C1**	**D1**	**E1**	**1,008**	**93,300,000**
A1	B2	C0	D2	E0	*inefficient*	
A0	**B3**	**C0**	**D2**	**E1**	**1,009**	**106,602,000**
A0	**B2**	**C1**	**D2**	**E0**	**1,014**	**107,848,359**
A1	**B1**	**C0**	**D2**	**E1**	**1,029**	**112,800,000**
A1	**B3**	**C0**	**D2**	**E1**	**1,465**	**127,102,000**
A1	**B2**	**C1**	**D2**	**E0**	**1,470**	**128,348,359**
A0	**B3**	**C1**	**D2**	**E1**	**1,471**	**125,602,000**
A1	**B1**	**C1**	**D2**	**E1**	**1,491**	**131,800,000**
A1	B3	C1	D0	E1	1,492	66,102,000
A1	**B2**	**C1**	**D1**	**E1**	**1,503**	**114,848,359**
A1	**B2**	**C1**	**D2**	**E1**	**1,530**	**132,848,359**
A1	**B3**	**C1**	**D1**	**E0**	**1,840**	**123,602,000**
A0	B4	C0	D0	E0	1,845	91,500,000
A1	**B3**	**C1**	**D2**	**E0**	**1,867**	**141,602,000**
A1	**B3**	**C1**	**D1**	**E1**	**1,900**	**128,102,000**
A0	B4	C0	D0	E1	1,905	96,000,000
A1	**B3**	**C1**	**D2**	**E1**	**1,927**	**146,102,000**
A0	**B4**	**C0**	**D1**	**E0**	**2,253**	**153,500,000**
A0	**B4**	**C0**	**D2**	**E0**	**2,280**	**171,500,000**
A1	**B4**	**C0**	**D0**	**E0**	**2,301**	**112,000,000**
A0	B4	C1	D0	E0	2,307	110,500,000
A0	**B4**	**C0**	**D1**	**E1**	**2,313**	**158,000,000**
A0	**B4**	**C0**	**D2**	**E1**	**2,340**	**176,000,000**
A1	**B4**	**C0**	**D0**	**E1**	**2,361**	**116,500,000**
A0	B4	C1	D0	E1	2,367	115,000,000
A1	**B4**	**C0**	**D1**	**E0**	**2,709**	**174,000,000**
A0	**B4**	**C1**	**D1**	**E0**	**2,715**	**172,500,000**
A1	**B4**	**C0**	**D2**	**E0**	**2,736**	**192,000,000**
A0	**B4**	**C1**	**D2**	**E0**	**2,742**	**190,500,000**
A1	B4	C1	D0	E0	2,763	131,000,000
A1	**B4**	**C0**	**D1**	**E1**	**2,769**	**178,500,000**
A0	**B4**	**C1**	**D1**	**E1**	**2,775**	**177,000,000**
A1	**B4**	**C0**	**D2**	**E1**	**2,796**	**196,500,000**
A0	**B4**	**C1**	**D2**	**E1**	**2,802**	**195,000,000**
A1	B4	C1	D0	E1	2,823	135,500,000
A1	B4	C1	D1	E0	3,171	193,000,000
A1	**B4**	**C1**	**D2**	**E0**	**3,198**	**211,000,000**
A1	B4	C1	D1	E1	3,231	197,500,000
A1	B4	C1	D2	E1	3,258	215,500,000

EXHIBIT STEP 5B: COST EFFECTIVE PLANS SORTED BY INCREASING OUTPUT LEVEL														
PLAN:					OUTPUT: (HUs)	COST: ($)	PLAN:					OUTPUT: (HUs)	COST: ($)
A0	B0	C0	D0	E0	0	0	A1	B0	C1	D0	E1	978	44,000,000
A0	B0	C0	D0	E1	60	4,500,000	A0	B3	C1	D0	E1	1,036	45,602,000
A0	B1	C0	D0	E0	78	7,800,000	A1	B1	C1	D0	E1	1,056	51,800,000
A0	B2	C0	D0	E0	117	8,848,359	A1	B2	C1	D0	E1	1,095	52,848,359
A0	B1	C0	D0	E1	138	12,300,000	A1	B3	C1	D0	E0	1,432	61,602,000
A0	B2	C0	D0	E1	177	13,348,359	A1	B3	C1	D0	E1	1,492	66,102,000
A0	B0	C1	D0	E0	462	19,000,000	A0	B4	C0	D0	E0	1,845	91,500,000
A0	B3	C0	D0	E0	514	22,102,000	A0	B4	C0	D0	E1	1,905	96,000,000
A0	B0	C1	D0	E1	522	23,500,000	A0	B4	C1	D0	E0	2,307	110,500,000
A0	B3	C0	D0	E1	574	26,602,000	A0	B4	C1	D0	E1	2,367	115,000,000
A0	B2	C1	D0	E0	579	27,848,359	A1	B4	C1	D0	E0	2,763	131,000,000
A0	B1	C1	D0	E1	600	31,300,000	A1	B4	C1	D0	E1	2,823	135,500,000
A0	B2	C1	D0	E1	639	32,348,359	A1	B4	C1	D1	E0	3,171	193,000,000
A1	B0	C1	D0	E0	918	39,500,000	A1	B4	C1	D1	E1	3,231	197,500,000
A0	B3	C1	D0	E0	976	41,102,000	A1	B4	C1	D2	E1	3,258	215,500,000

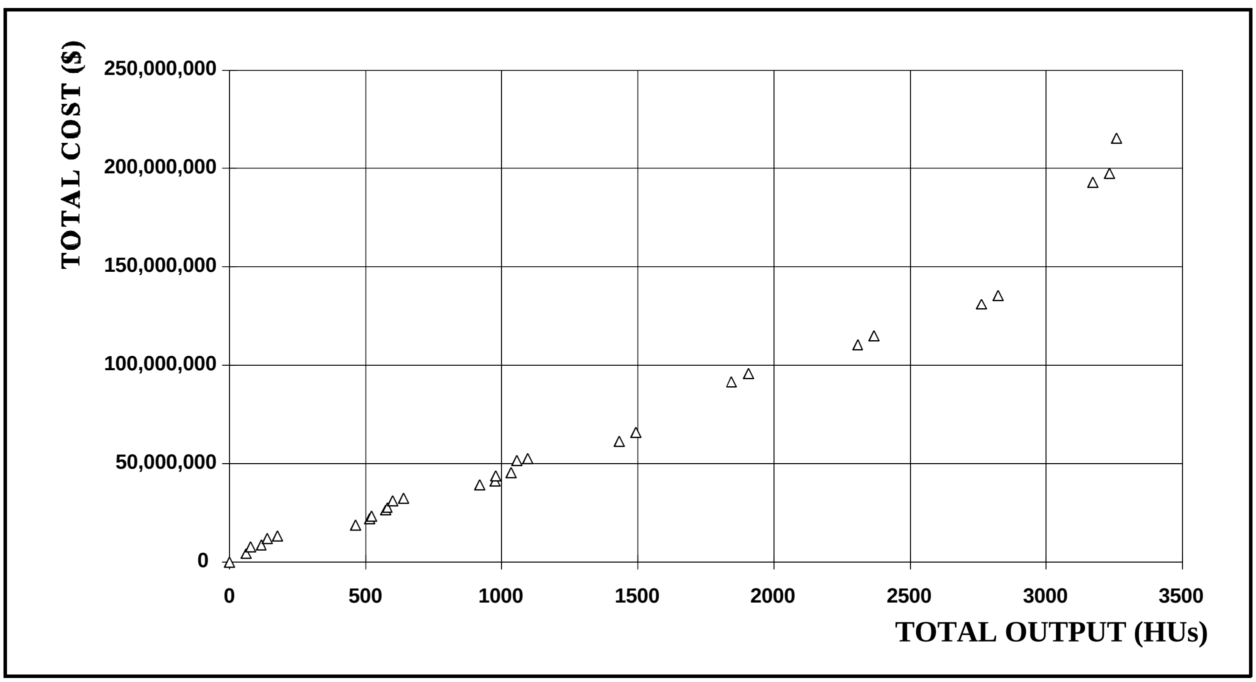


EXHIBIT STEP 5C: COST AND OUTPUT OF COST EFFECTIVE PLANS

Step 6 - Calculate and Display Incremental Costs

In this step we will compute the incremental cost, incremental output, and incremental cost per unit of advancing to each successive cost effective output level. The computational procedures for computing incremental cost, incremental output, and incremental cost per unit are the same as described in Chapter Two. Exhibit Step 6A contains a table of these incremental values.

EXHIBIT STEP 6A: INCREMENTAL VALUES FOR EACH SUCCESSIVE COST EFFECTIVE PLAN

PLAN:					OUTPUT: (HUs)	COST: ($)	INCREMENTAL OUTPUT: (HUs)	INCREMENTAL COST: ($)	INCREMENTAL COST PER UNIT: ($/HU)
A0	B0	C0	D0	E0	0	0			
A0	B0	C0	D0	E1	60	4,500,000	60	4,500,000	75,000
A0	B1	C0	D0	E0	78	7,800,000	18	3,300,000	183,333
A0	B2	C0	D0	E0	117	8,848,359	39	1,048,359	26,881
A0	B1	C0	D0	E1	138	12,300,000	21	3,451,641	164,364
A0	B2	C0	D0	E1	177	13,348,359	39	1,048,359	26,881
A0	B0	C1	D0	E0	462	19,000,000	285	5,651,641	19,830
A0	B3	C0	D0	E0	514	22,102,000	52	3,102,000	59,654
A0	B0	C1	D0	E1	522	23,500,000	8	1,398,000	174,750
A0	B3	C0	D0	E1	574	26,602,000	52	3,102,000	59,654
A0	B2	C1	D0	E0	579	27,848,359	5	1,246,359	249,272
A0	B1	C1	D0	E1	600	31,300,000	21	3,451,641	164,364
A0	B2	C1	D0	E1	639	32,348,359	39	1,048,359	26,881
A1	B0	C1	D0	E0	918	39,500,000	279	7,151,641	25,633
A0	B3	C1	D0	E0	976	41,102,000	58	1,602,000	27,621
A1	B0	C1	D0	E1	978	44,000,000	2	2,898,000	1,449,000
A0	B3	C1	D0	E1	1,036	45,602,000	58	1,602,000	27,621
A1	B1	C1	D0	E1	1,056	51,800,000	20	6,198,000	309,900
A1	B2	C1	D0	E1	1,095	52,848,359	39	1,048,359	26,881
A1	B3	C1	D0	E0	1,432	61,602,000	337	8,753,641	25,975
A1	B3	C1	D0	E1	1,492	66,102,000	60	4,500,000	75,000
A0	B4	C0	D0	E0	1,845	91,500,000	353	25,398,000	71,949
A0	B4	C0	D0	E1	1,905	96,000,000	60	4,500,000	75,000
A0	B4	C1	D0	E0	2,307	110,500,000	402	14,500,000	36,070
A0	B4	C1	D0	E1	2,367	115,000,000	60	4,500,000	75,000
A1	B4	C1	D0	E0	2,763	131,000,000	396	16,000,000	40,404
A1	B4	C1	D0	E1	2,823	135,500,000	60	4,500,000	75,000
A1	B4	C1	D1	E0	3,171	193,000,000	348	57,500,000	165,230
A1	B4	C1	D1	E1	3,231	197,500,000	60	4,500,000	75,000
A1	B4	C1	D2	E1	3,258	215,500,000	27	18,000,000	666,667

Exhibit Step 6B contains a graph of the incremental cost per unit and the incremental output of each plan over the plan (output level) preceding it. In Exhibit Step 6B, while the height of each bar shows the incremental cost per unit, the width of the bar is not to scale with the corresponding incremental output. This is due to the difficulties in displaying a two dimensional bar graph with this many data points. The two numerical labels beneath each bar represent the incremental output and the total output (respectively) provided by the corresponding plan.

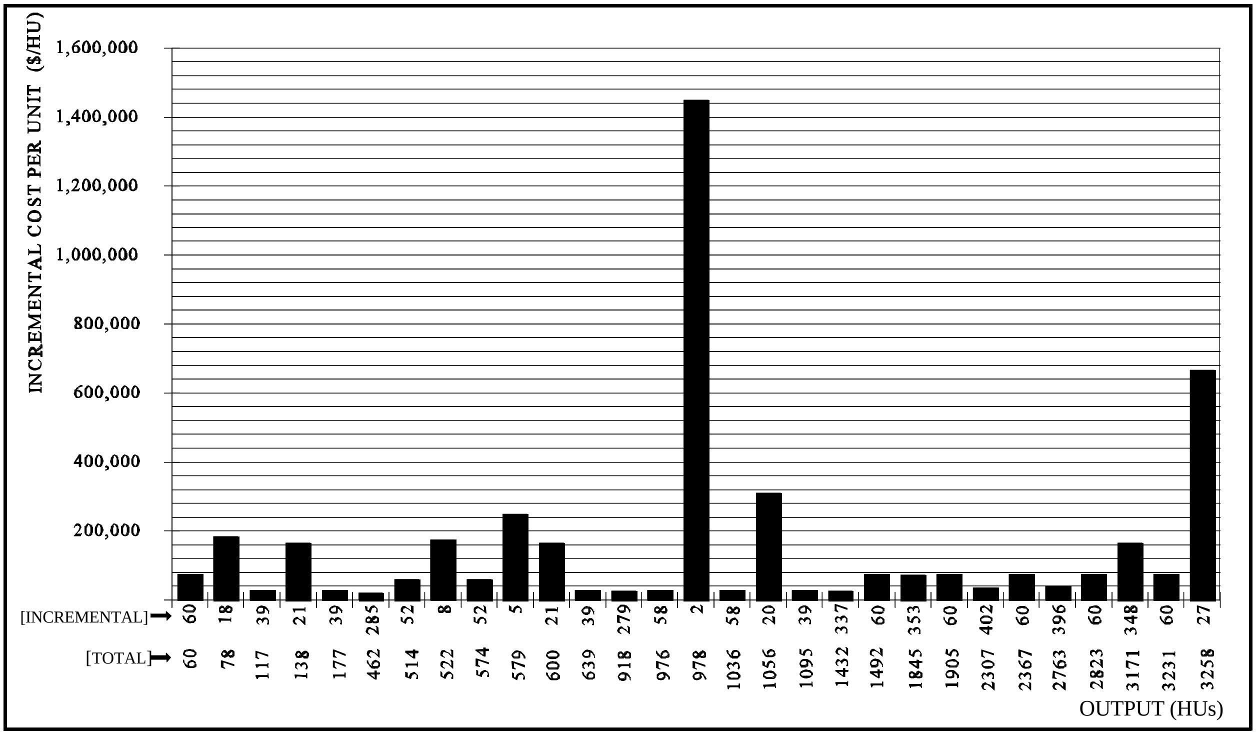


EXHIBIT STEP 6B INCREMENTAL COST PER UNIT AND INCREMENTAL OUTPUT FOR EACH SUCCESSIVE COST EFFECTIVE OUTPUT LEVEL

The objectives of Exhibits 6A and 6B are to provide information to assist in determining whether the additional output provided by each successive plan is worth the additional cost that must be incurred to implement it; that is, to assist in determining the scale of the recommended plan.

Idealistically, the resultant table (Exhibit 6A) and graph (Exhibit 6B) would include continuously increasing incremental costs per unit as we move to successively larger output levels, such as illustrated on Figure 3-3, page 39. Continuously increasing incremental costs per unit facilitate answering the “is it worth it?” question as we compare successively larger-scaled plans. This is because when each successive plan provides more output than previous plans, and that additional output costs more per unit than preceding plans (increasing incremental costs per unit), it is intuitive to ask if the additional output is worth its higher unit cost.

Realistically, however, in most actual planning studies, an incremental cost curve with irregularly increasing and decreasing incremental costs per unit will result, such as displayed in Exhibit 6B. These are often referred to as “lumpy” cost data. These lumpy data primarily result because, even though a large number of alternatives may have been considered, they represent only a subset of the infinite number of alternatives that are available to develop a continuous incremental cost curve. Such a curve would, most likely, include continuously increasing incremental costs per unit.

Although such "lumpy" data may be useful in analyzing segments of the incremental curve (for example, is it worth it to provide 2 additional units at a cost of $1,449,000 each over a plan that would provide 976 units), they aren't very helpful in determining the overall recommended scale. If, as we increase project scale, we are faced with fluctuating ("lumpy") data on incremental cost per unit that make the selection of the appropriate project scale unclear, it may be useful to employ the following Steps Seven through Nine. These steps "smooth out" fluctuating incremental costs per unit through a different analytical processing, helping to illuminate the information on the incremental cost curve. The analytical processes for smoothing the curve are based upon the identification of plans which capture production efficiencies along segments of the curve. There is no need to utilize steps Seven through Nine if the incremental cost per unit is continuously increasing across all cost effective plans.

Step 7 - Calculate Incremental Cost Per Unit of Moving from the "No-Action" Plan to Each Remaining Plan

To smooth out fluctuations in incremental costs per unit as project scale increases such that they are continuously increasing, we can employ a variation on incremental cost analysis that will result in a smaller range of alternative plans for consideration where each successive plan (output level) has a larger incremental cost per unit. The procedures for smoothing the curve are described in Steps Seven through Nine. The first task in this procedure is to determine the change in output and change in cost resulting from implementing each plan instead of the no-action plan.

In this step of the "smoothing" process, we are now comparing the incremental cost and incremental output of all plans over the no-action plan. Here, the no-action plan can be thought of as the baseline condition which each other plan is compared to. Comparisons of the incremental cost *and* incremental output of plans can be accomplished by looking at the incremental cost per unit of each plan over the "baseline condition". As an arbitrary, but informed, decision rule, we will select the plan with the lowest incremental cost per unit (it is the "best deal" from a production perspective, producing output at the lowest unit cost) and then remove from further consideration (in this analytical process) any plans that provide a smaller output level than the selected plan (they are less efficient in production, producing a lower level of output at a higher unit cost).

The formula for computing incremental cost per unit for each plan over the no-action plan is included in Figure 3-5. When the no-action plan is associated with a $0 cost level and a 0 unit output level, then the incremental cost per unit of each plan over the no-action plan is equivalent to the average cost of each alternative; (i.e., $COST_i$ / $OUTPUT_i$). This is the case in our example; that is, the no-action plan had a $0 cost and a 0 habitat unit output level. The incremental average cost of each remaining alternative over the no-action plan is included in Exhibit Step 7.

$$\text{INCREMENTAL COST PER UNIT}_i = \frac{\text{COST}_i - \text{COST}_{NA}}{\text{OUTPUT}_i - \text{OUTPUT}_{NA}}$$

Where:
NA = no action plan; and
i = alternative plan under consideration

Figure 3-5 Formula for Incremental Cost Per Unit of Each Plan over No Action Plan

Notice that in Exhibit Step 7, the alternatives are sorted in order of increasing output. We can now scan the incremental cost per unit column of Exhibit Step 7 to find the plan with the lowest incremental cost per unit beyond the no-action plan. This is plan [A0 + B0 + C1 + D0 + E0], the "best deal" for production of habitat units beyond the no-action plan, producing additional habitat units at an additional cost of $41,126 each. We will now delete plans [A0 + B0 + C0 + D0 + E1], [A0 + B1 + C0 + D0 + E0], [A0 + B2 + C0 + D0 + E0], [A0 + B1 + C0 + D0 + E1], and [A0 + B2 + C0 + D0 + E1] from further consideration.

EXHIBIT STEP 7: INCREMENTAL COST PER UNIT OF IMPLEMENTING EACH REMAINING PLAN INSTEAD OF NO ACTION PLAN
[SELECTED PLANS OUTLINED]
[ELIMINATED PLANS SHADED]

PLAN:					OUTPUT: (HUs)	COST: ($)	INCREMENTAL OUTPUT: (HUs)	INCREMENTAL COST: ($)	INCREMENTAL COST PER UNIT: ($/HU)
A0	*B0*	*C0*	*D0*	*E0*	*0*	*0*	*not applicable*	*not applicable*	*not applicable*
A0	**B0**	**C0**	**D0**	**E1**	**60**	**4,500,000**	**60**	**4,500,000**	**75,000**
A0	**B1**	**C0**	**D0**	**E0**	**78**	**7,800,000**	**78**	**7,800,000**	**100,000**
A0	**B2**	**C0**	**D0**	**E0**	**117**	**8,848,359**	**117**	**8,848,359**	**75,627**
A0	**B1**	**C0**	**D0**	**E1**	**138**	**12,300,000**	**138**	**12,300,000**	**89,130**
A0	**B2**	**C0**	**D0**	**E1**	**177**	**13,348,359**	**177**	**13,348,359**	**75,414**
A0	B0	C1	D0	E0	462	19,000,000	462	19,000,000	41,126
A0	B3	C0	D0	E0	514	22,102,000	514	22,102,000	43,000
A0	B0	C1	D0	E1	522	23,500,000	522	23,500,000	45,019
A0	B3	C0	D0	E1	574	26,602,000	574	26,602,000	46,345
A0	B2	C1	D0	E0	579	27,848,359	579	27,848,359	48,097
A0	B1	C1	D0	E1	600	31,300,000	600	31,300,000	52,167
A0	B2	C1	D0	E1	639	32,348,359	639	32,348,359	50,623
A1	B0	C1	D0	E0	918	39,500,000	918	39,500,000	43,028
A0	B3	C1	D0	E0	976	41,102,000	976	41,102,000	42,113
A1	B0	C1	D0	E1	978	44,000,000	978	44,000,000	44,990
A0	B3	C1	D0	E1	1,036	45,602,000	1,036	45,602,000	44,017
A1	B1	C1	D0	E1	1,056	51,800,000	1,056	51,800,000	49,053
A1	B2	C1	D0	E1	1,095	52,848,359	1,095	52,848,359	48,263
A1	B3	C1	D0	E0	1,432	61,602,000	1,432	61,602,000	43,018
A1	B3	C1	D0	E1	1,492	66,102,000	1,492	66,102,000	44,304
A0	B4	C0	D0	E0	1,845	91,500,000	1,845	91,500,000	49,593
A0	B4	C0	D0	E1	1,905	96,000,000	1,905	96,000,000	50,394
A0	B4	C1	D0	E0	2,307	110,500,000	2,307	110,500,000	47,898
A0	B4	C1	D0	E1	2,367	115,000,000	2,367	115,000,000	48,585
A1	B4	C1	D0	E0	2,763	131,000,000	2,763	131,000,000	47,412
A1	B4	C1	D0	E1	2,823	135,500,000	2,823	135,500,000	47,999
A1	B4	C1	D1	E0	3,171	193,000,000	3,171	193,000,000	60,864
A1	B4	C1	D1	E1	3,231	197,500,000	3,231	197,500,000	61,127
A1	B4	C1	D2	E1	3,258	215,500,000	3,258	215,500,000	66,145

Step 8 - Recalculate Incremental Cost per Unit of Implementing Each Remaining Plan Instead of Last Seleted Plan

This calculation is the same as the calculation performed in the last step, Step 7, to determine the incremental cost per unit of each alternative over the no-action plan except that now we are calculating the incremental cost per unit of each remaining plan over that of the the last plan selected. The adapted formula is included in Figure 3-6.

$$\text{INCREMENTAL COST PER UNIT}_i = \frac{\text{COST}_i - \text{COST}_{SP}}{\text{OUTPUT}_i - \text{OUTPUT}_{SP}}$$

Where:

SP = last selected plan; and
i = each remaining plan

Figure 3-6 Formula for Incremental Cost Per Unit of Each Remaining Plan over Last Selected Plan

After recalculating the incremental cost per unit for each remaining plan over the last selected plan, again we will select the alternative with the lowest incremental cost per unit and shade all plans that produce lower output levels at higher incremental unit cost for deletion from further analysis. The results of this process are included as Exhibit Step 8A.

Here, we select plan [A0 + B3 + C1 + D0 + E0], which has the lowest remaining incremental cost per unit ($43,000 per unit) over the last selected plan. Again, we delete all plans producing less output at a higher incremental unit cost than that of plan [A0 + B3 + C1 + D0 + E0] from further analyses. This process of recalculating incremental cost per unit for each remaining plan over the last selected plan is reiterated until we recalculate incremental unit cost for the last remaining plan. The number of iterations is dependent upon the number of plans and on the respective cost and output data on each. In our example, this process requires a total of six iterations. The results of the last five iterations are included as exhibit Steps 8B-F.

EXHIBIT STEP 8A: INCREMENTAL COST PER UNIT OF IMPLEMENTING EACH REMAINING PLAN INSTEAD OF LAST SELECTED PLAN
[SELECTED PLANS OUTLINED] [LAST SELECTED PLAN IN ITALICS]
[ELIMINATED PLANS SHADED]

PLAN:					OUTPUT: (HUs)	COST: ($)	INCREMENTAL OUTPUT: (HUs)	INCREMENTAL COST: ($)	INCREMENTAL COST PER UNIT: ($/HU)
A0	B0	C0	D0	E0	0	0	not applicable	not applicable	not applicable
A0	*B0*	*C1*	*D0*	*E0*	*462*	*19,000,000*	*462*	*19,000,000*	*41,126*
A0	**B3**	**C0**	**D0**	**E0**	**514**	**22,102,000**	**52**	**3,102,000**	**59,654**
A0	**B0**	**C1**	**D0**	**E1**	**522**	**23,500,000**	**60**	**4,500,000**	**75,000**
A0	**B3**	**C0**	**D0**	**E1**	**574**	**26,602,000**	**112**	**7,602,000**	**67,875**
A0	**B2**	**C1**	**D0**	**E0**	**579**	**27,848,359**	**117**	**8,848,359**	**75,627**
A0	**B1**	**C1**	**D0**	**E1**	**600**	**31,300,000**	**138**	**12,300,000**	**89,130**
A0	**B2**	**C1**	**D0**	**E1**	**639**	**32,348,359**	**177**	**13,348,359**	**75,414**
A1	**B0**	**C1**	**D0**	**E0**	**918**	**39,500,000**	**456**	**20,500,000**	**44,956**
A0	B3	C1	D0	E0	976	41,102,000	514	22,102,000	43,000
A1	B0	C1	D0	E1	978	44,000,000	516	25,000,000	48,450
A0	B3	C1	D0	E1	1,036	45,602,000	574	26,602,000	46,345
A1	B1	C1	D0	E1	1,056	51,800,000	594	32,800,000	55,219
A1	B2	C1	D0	E1	1,095	52,848,359	633	33,848,359	53,473
A1	B3	C1	D0	E0	1,432	61,602,000	970	42,602,000	43,920
A1	B3	C1	D0	E1	1,492	66,102,000	1,030	47,102,000	45,730
A0	B4	C0	D0	E0	1,845	91,500,000	1,383	72,500,000	52,422
A0	B4	C0	D0	E1	1,905	96,000,000	1,443	77,000,000	53,361
A0	B4	C1	D0	E0	2,307	110,500,000	1,845	91,500,000	49,593
A0	B4	C1	D0	E1	2,367	115,000,000	1,905	96,000,000	50,394
A1	B4	C1	D0	E0	2,763	131,000,000	2,301	112,000,000	48,674
A1	B4	C1	D0	E1	2,823	135,500,000	2,361	116,500,000	49,343
A1	B4	C1	D1	E0	3,171	193,000,000	2,709	174,000,000	64,230
A1	B4	C1	D1	E1	3,231	197,500,000	2,769	178,500,000	64,464
A1	B4	C1	D2	E1	3,258	215,500,000	2,796	196,500,000	70,279

EXHIBIT STEP 8B: INCREMENTAL COST PER UNIT OF IMPLEMENTING EACH REMAINING PLAN INSTEAD OF LAST SELECTED PLAN
[SELECTED PLANS OUTLINED] [LAST SELECTED PLAN IN ITALICS]
[ELIMINATED PLANS SHADED]

PLAN:					OUTPUT: (HUs)	COST: ($)	INCREMENTAL OUTPUT: (HUs)	INCREMENTAL COST: ($)	INCREMENTAL COST PER UNIT: ($/HU)
A0	B0	C0	D0	E0	0	0	not applicable	not applicable	not applicable
A0	B0	C1	D0	E0	462	19,000,000	462	19,000,000	41,126
A0	*B3*	*C1*	*D0*	*E0*	*976*	*41,102,000*	*514*	*22,102,000*	*43,000*
A1	**B0**	**C1**	**D0**	**E1**	**978**	**44,000,000**	**2**	**2,898,000**	**1,449,000**
A0	**B3**	**C1**	**D0**	**E1**	**1,036**	**45,602,000**	**60**	**4,500,000**	**75,000**
A1	**B1**	**C1**	**D0**	**E1**	**1,056**	**51,800,000**	**80**	**10,698,000**	**133,725**
A1	**B2**	**C1**	**D0**	**E1**	**1,095**	**52,848,359**	**119**	**11,746,359**	**98,709**
A1	B3	C1	D0	E0	1,432	61,602,000	456	20,500,000	44,956
A1	B3	C1	D0	E1	1,492	66,102,000	516	25,000,000	48,450
A0	B4	C0	D0	E0	1,845	91,500,000	869	50,398,000	57,995
A0	B4	C0	D0	E1	1,905	96,000,000	929	54,898,000	59,094
A0	B4	C1	D0	E0	2,307	110,500,000	1,331	69,398,000	52,140
A0	B4	C1	D0	E1	2,367	115,000,000	1,391	73,898,000	53,126
A1	B4	C1	D0	E0	2,763	131,000,000	1,787	89,898,000	50,307
A1	B4	C1	D0	E1	2,823	135,500,000	1,847	94,398,000	51,109
A1	B4	C1	D1	E0	3,171	193,000,000	2,195	151,898,000	69,202
A1	B4	C1	D1	E1	3,231	197,500,000	2,255	156,398,000	69,356
A1	B4	C1	D2	E1	3,258	215,500,000	2,282	174,398,000	76,423

EXHIBIT STEP 8C: INCREMENTAL COST PER UNIT OF IMPLEMENTING EACH REMAINING PLAN INSTEAD OF LAST SELECTED PLAN
[SELECTED PLANS OUTLINED] [LAST SELECTED PLAN IN ITALICS]
[ELIMINATED PLANS SHADED]

PLAN:					OUTPUT: (HUs)	COST: ($)	INCREMENTAL OUTPUT: (HUs)	INCREMENTAL COST: ($)	INCREMENTAL COST PER UNIT: ($/HU)
A0	B0	C0	D0	E0	0	0	not applicable	not applicable	not applicable
A0	B0	C1	D0	E0	462	19,000,000	462	19,000,000	41,126
A0	B3	C1	D0	E0	976	41,102,000	514	22,102,000	43,000
A1	*B3*	*C1*	*D0*	*E0*	*1,432*	*61,602,000*	*456*	*20,500,000*	*44,956*
A1	**B3**	**C1**	**D0**	**E1**	**1,492**	**66,102,000**	**60**	**4,500,000**	**75,000**
A0	**B4**	**C0**	**D0**	**E0**	**1,845**	**91,500,000**	**413**	**29,898,000**	**72,392**
A0	**B4**	**C0**	**D0**	**E1**	**1,905**	**96,000,000**	**473**	**34,398,000**	**72,723**
A0	**B4**	**C1**	**D0**	**E0**	**2,307**	**110,500,000**	**875**	**48,898,000**	**55,883**
A0	**B4**	**C1**	**D0**	**E1**	**2,367**	**115,000,000**	**935**	**53,398,000**	**57,110**
A1	B4	C1	D0	E0	2,763	131,000,000	1,331	69,398,000	52,140
A1	B4	C1	D0	E1	2,823	135,500,000	1,391	73,898,000	53,126
A1	B4	C1	D1	E0	3,171	193,000,000	1,739	131,398,000	75,560
A1	B4	C1	D1	E1	3,231	197,500,000	1,799	135,898,000	75,541
A1	B4	C1	D2	E1	3,258	215,500,000	1,826	153,898,000	84,281

EXHIBIT STEP 8D: INCREMENTAL COST PER UNIT OF IMPLEMENTING EACH REMAINING PLAN INSTEAD OF LAST SELECTED PLAN

[SELECTED PLANS OUTLINED] [LAST SELECTED PLAN IN ITALICS]
[ELIMINATED PLANS SHADED]

PLAN:					OUTPUT: (HUs)	COST: ($)	INCREMENTAL OUTPUT: (HUs)	INCREMENTAL COST: ($)	INCREMENTAL COST PER UNIT: ($/HU)
A0	B0	C0	D0	E0	0	0	not applicable	not applicable	not applicable
A0	B0	C1	D0	E0	462	19,000,000	462	19,000,000	41,126
A0	B3	C1	D0	E0	976	41,102,000	514	22,102,000	43,000
A1	B3	C1	D0	E0	1,432	61,602,000	456	20,500,000	44,956
A1	*B4*	*C1*	*D0*	*E0*	*2,763*	*131,000,000*	*1,331*	*69,398,000*	*52,140*
A1	B4	C1	D0	E1	2,823	135,500,000	60	4,500,000	75,000
A1	B4	C1	D1	E0	3,171	193,000,000	408	62,000,000	151,961
A1	B4	C1	D1	E1	3,231	197,500,000	468	66,500,000	142,094
A1	B4	C1	D2	E1	3,258	215,500,000	495	84,500,000	170,707

EXHIBIT STEP 8E: INCREMENTAL COST PER UNIT OF IMPLEMENTING EACH REMAINING PLAN INSTEAD OF LAST SELECTED PLAN [SELECTED PLANS OUTLINED] [LAST SELECTED PLAN IN ITALICS] [ELIMINATED PLANS SHADED]										
PLAN:					OUTPUT: (HUs)	COST: ($)	INCREMENTAL OUTPUT: (HUs)	INCREMENTAL COST: ($)	INCREMENTAL COST PER UNIT: ($/HU)
A0	B0	C0	D0	E0	0	0	not applicable	not applicable	not applicable
A0	B0	C1	D0	E0	462	19,000,000	462	19,000,000	41,126
A0	B3	C1	D0	E0	976	41,102,000	514	22,102,000	43,000
A1	B3	C1	D0	E0	1,432	61,602,000	456	20,500,000	44,956
A1	B4	C1	D0	E0	2,763	131,000,000	1,331	69,398,000	52,140
A1	*B4*	*C1*	*D0*	*E1*	*2,823*	*135,500,000*	*60*	*4,500,000*	*75,000*
A1	**B4**	**C1**	**D1**	**E0**	**3,171**	**193,000,000**	**348**	**57,500,000**	**165,230**
A1	B4	C1	D1	E1	3,231	197,500,000	408	62,000,000	151,961
A1	B4	C1	D2	E1	3,258	215,500,000	435	80,000,000	183,908

EXHIBIT STEP 8F: INCREMENTAL COST PER UNIT OF IMPLEMENTING EACH REMAINING PLAN INSTEAD OF LAST SELECTED PLAN
[SELECTED PLANS OUTLINED] [LAST SELECTED PLAN IN ITALICS]
[ELIMINATED PLANS SHADED]

PLAN:					OUTPUT: (HUs)	COST: ($)	INCREMENTAL OUTPUT: (HUs)	INCREMENTAL COST: ($)	INCREMENTAL COST PER UNIT: ($/HU)
A0	B0	C0	D0	E0	0	0	not applicable	not applicable	not applicable
A0	B0	C1	D0	E0	462	19,000,000	462	19,000,000	41,126
A0	B3	C1	D0	E0	976	41,102,000	514	22,102,000	43,000
A1	B3	C1	D0	E0	1,432	61,602,000	456	20,500,000	44,956
A1	B4	C1	D0	E0	2,763	131,000,000	1,331	69,398,000	52,140
A1	B4	C1	D0	E1	2,823	135,500,000	60	4,500,000	75,000
A1	*B4*	*C1*	*D1*	*E1*	*3,231*	*197,500,000*	*408*	*62,000,000*	*151,961*
A1	B4	C1	D2	E1	3,258	215,500,000	27	18,000,000	666,667

It should be noted again that the "smoothing process", described in Steps Seven and Eight, is an arbitrary, but rational, decision process based upon production efficiency. Situations could arise where the most efficient plan, from a production perspective, produces such a large quantity of output that it's total cost makes it unfeasible due to cost constraints. However, because the plan is the most efficient in production, all plans that produce smaller output levels (possibly at lower and acceptable total cost levels) would be eliminated from consideration in this smoothing process. In such situations, it may be useful to remove such a prohibitively large scale plan from consideration and reiterate the smoothing process. The purpose of the smoothing process is not to eliminate plans from the possibility of being selected, but rather to identify those plans (and their corresponding level of output) where there is a marked increase in production costs. By identifying where significant increases in production costs occur as we increase output levels, we provide information to assist in determining desirable project scale.

Step 9 - Tabulate and Graph Incremental Costs

The information found in Exhibit Step 8F is the input for our "illuminated" incremental cost analysis. Step 9 tabulates and graphs the data computed in Steps 7 - 8 into a format such that it is more useful input for the decision making processes to follow. Exhibit Step 9A includes the remaining plans, and the respective cost, output, average cost, incremental cost, incremental output, and incremental cost per unit of each. Exhibit Step 9B presents the information on output and incremental average cost in a graphical format.

DECISION GUIDELINES

Federal planning for water resources development is conducted in accordance with the requirements of the P&G. The P&G provide a decision rule for selecting a recommended plan where both outputs and costs are measured in dollars. This rule states that "the alternative plan with the greatest net economic benefit consistent with protecting the Nation's environment (National Economic Development Plan, NED Plan) is to be selected..." (paragraph 1.10.2). There is *no similar rule* for plan selection where outputs are not measured in dollars, as is the case in planning for restoration and mitigation.

Neither cost effectiveness analysis nor incremental cost analysis include a plan selection rule similar to the traditional NED rule. In the absence of such a decision making rule, neither analysis will tell you what choice to make. However, the information developed by both analyses will help you make better-informed decisions; and, once a decision is made, they will help you to better understand its consequences in relation to your other choices.

For example, the Step 9 exhibits can be used as decision making tools by progressively proceeding through the available levels of outputs and asking if the next level is "worth it"; that is, is the habitat value of the additional output in the next level of output worth its additional cost? In the first comparison, the first level of output is 462 habitat units, which could be produced at an additional, or incremental, cost of $41,125 each; as opposed to 0 habitat units at $0 each. If decision makers determine

EXHIBIT STEP 9A: SUMMARY DATA FOR INCREMENTAL COST ANALYSIS

PLAN:					COST: ($)	OUTPUT: (HUs)	AVERAGE COST: ($/HU)	INCREMENTAL COST: ($)	INCREMENTAL OUTPUT: (HUs)	INCREMENTAL COST PER UNIT: ($/HU)
A0	B0	C0	D0	E0	0	0	not applicable	not applicable	not applicable	not applicable
A0	B0	C1	D0	E0	19,000,000	462	41,126	19,000,000	462	41,126
A0	B3	C1	D0	E0	41,102,000	976	42,113	22,102,000	514	43,000
A1	B3	C1	D0	E0	61,602,000	1,432	43,018	20,500,000	456	44,956
A1	B4	C1	D0	E0	131,000,000	2,763	47,412	69,398,000	1,331	52,140
A1	B4	C1	D0	E1	135,500,000	2,823	47,999	4,500,000	60	75,000
A1	B4	C1	D1	E1	197,500,000	3,231	61,127	62,000,000	408	151,961
A1	B4	C1	D2	E1	215,500,000	3,258	66,145	18,000,000	27	666,667

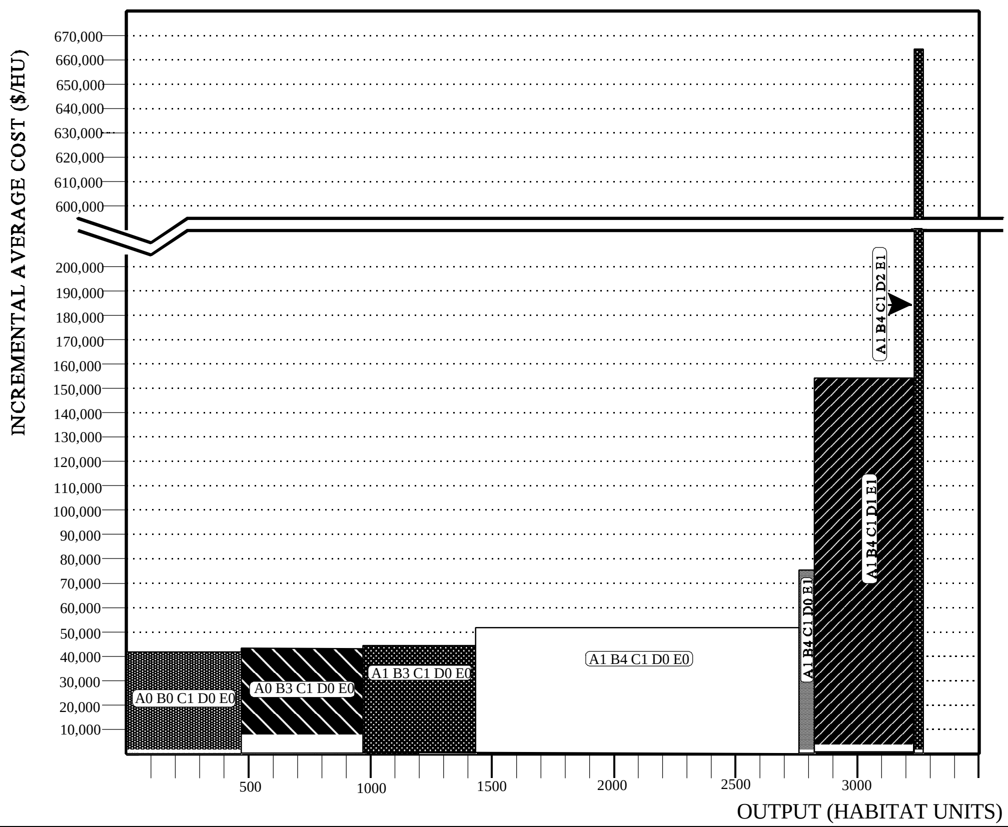


EXHIBIT STEP 9B INCREMENTAL COST DISPLAY GRAPH

that 462 habitat units are worth $41,125 each, then we proceed to the next level of output and repeat the questioning. If not, we would stick with the no-action plan. Let's assume that decision makers found the first

462 habitat units to be worth their cost; we would then proceed to the next output level. At this level, we get a total of 976 habitat units, or 514 additional habitat units over the last level at a cost of $43,000 for each additional habitat unit. Again, if decision makers determine that the additional 514 habitat units are worth $43,000 each, then we would proceed to the next level.

Often, this questioning process will tend to continue to conclude that successive levels of output are "worth it" until an unusual increase in incremental costs, beyond the general range of preceding costs, is encountered. For example, incremental unit costs range between $41,125 per habitat unit to $44,956 per habitat unit for all available levels of output up to 1432 habitat units. An increase to the next available level after 1432 habitat units, 2763 habitat units, (an increase of 1331 habitat units) would incur an additional cost of $69,398,000, or $52,140 each. This relatively larger increase in unit cost for additional output could present decision makers with a situation where the value of increasing outputs to this level may need to be explained, supported and considered in more detail than previous increases. In some cases, the additional output may not be worth the additional cost; in some cases it may be worth the additional cost. If a level of output is determined to be "not worth it", then subsequent levels of output will also probably be not "worth it" and the final decision about project scale has been reached.

However, if the additional cost is determined to be justified, then the process should proceed to the next available level of output, 2823 habitat units, providing 60 additional habitat units at an incremental unit cost of $75,000 each. If this large jump in incremental unit cost is to be justified, even more explanation, support, and detail may need to be provided. The rationale is the same for proceeding to the remaining output levels. For example, the 27 additional units provided by the last plan, [A1 + B4 + C1 + D2 + E1] cost $666,667 each.

While there is no direct parallel to the traditional NED rule for selecting environmental solutions, the following general decision making guidelines related to outputs, costs and the display curves can use the results of cost effectiveness and incremental cost analyses to assist in making the "Is it worth it?" decisions:

> ***Curve Anomalies:*** Abrupt changes in an incremental cost curve identify potential decision points for focusing the "Is it worth it?" questioning process. Changes in the curve (or, as used in these procedures, the bars in the incremental cost bar graphs) are referred to as a breakpoint, a spike, a peak, a jump, or the "knee of the curve"; and occur where an incremental cost increases relatively sharply in contrast to preceding or following incremental costs. These points provide decision makers with reasons to question the causes of the changes, and whether the additional incremental costs are "worth it". For example, is there a change in the management measures that comprise the solution, or is a large increase in output or cost due to an increase in the size of a management measure? Such situations may provide persuasive reasons for accepting large increases in incremental costs.
>
> ***Output Target:*** If a study has established a specific resource output target to be met, then a decision rule could be developed to meet some portion of that target. For example, if an alternative plan's adverse effect on a cypress-tupelo swamp were to be identified as a loss of 25 HU, then the 100% mitigation target would be 25 HU. The HU target could be marked on a incremental cost bar graph (like Exhibit Step 8B) to provide a picture of the relationship between the target and the possible solutions. This display may be useful to decision makers by focusing the "Is it worth it"? questioning process (Step 9) on the HU target, and asking if the incremental costs of the solutions that lead to the target are worth

it. If getting to the HU target is judged to be "worth it", then decision makers may continue to consider solutions beyond the target until it was finally judged to no longer be "worth it" to produce any additional HU output.

A target should be considered a goal to strive for; in most cases it is not an absolute that must be achieved because it may be unrealistic and may establish expectations that cannot be met. For example, while full restoration of a previous ecological condition may be an ideal target, in many cases it would be both impossible and unacceptable to achieve due to the disruption of human development that would have to be accommodated to achieve it.

A special "target" is required for adverse effects on wetlands, which are to be "fully mitigated"through actions to avoid, minimize and compensate for unavoidable losses to meet the goal of a no net loss of wetlands (Water Resources Development Act of 1990, Section 307(a); ER 1105-2-100, paragraph 7-35g). In this special case, the decision rule might be to mitigate 100% of a wetland loss.

Output Thresholds: In some cases it may be necessary to first produce a minimum base amount of output, and any lesser amount would not be successful. For example, a certain habitat community may require a minimum area of 2,000 acres to support the range of a key species, and any area less than that threshold would not be adequate. In such cases, a minimum level of output should be considered, and only solutions that would meet or exceed the minimum output threshold would be considered. Similarly there may also exist a "maximum threshold" level of output where production beyond that output level threshold would no longer contribute to the achievement of planning objectives. If minimum or maximum output thresholds exist, they can be utilized to bound the range of acceptable solutions.

Cost Affordability: If implementation funds are a constraint, then decision makers can review both the cost effectiveness curve and the incremental cost curve for information that will help them judge the "best investment" for the funds available. For example, if only $65,000,000 is available for a restoration effort, then, by examining the Exhibit Steps 5B and 5C, (i.e., cost effective, least cost alternatives' data and curve), decision makers could see that alternative [A1 + B3 + C1 + D0 + E] solution is the largest solution that could be funded, and that it would produce 1,432 HUs at a total cost of $61,602,000. By further reviewing the Exhibit Step 8B incremental cost bar graph, decision makers could see the incremental cost increases that lead to [A1 + B3 + C1 + D0 + E0]; and they could then ask if, in their judgment, the 1,432 HUs would be the best investment for the funds available.

The results of cost effectiveness and incremental cost analyses are intended to help decision makers make better informed decisions. However, although you are required to conduct the analyses, there is no requirement to select a solution from the final set of solutions as illustrated in Step Nine of this nine step procedure. Other solutions, identified as non-cost effective (that is, "production-ineffective" or "production-inefficient") in cost effectiveness analysis; as well as cost effective plans, identified as relatively less efficient in production in Steps Seven and Eight, may continue to be considered for selection. For example look at Figure 3-7, which shows all combinations (plans) from our previous exercise.

The graph in Figure 3-7 is a modified version of Exhibit Step 3B, where now, different symbols are used to indicate: 1) non-cost effective plans, 2) cost effective plans, and 3) cost effective plans identified as most efficient in production through the smoothing process in Steps Seven and Eight. The points plotted on this graph show all the options available to select from. If a plan is chosen that is above the cost-effectiveness frontier on this graph, that selection may need to be based upon an explicit rationale as to why the additional cost incurred is a good investment.

The selection of a plan above the cost effectiveness frontier may be appropriate in some situations. In

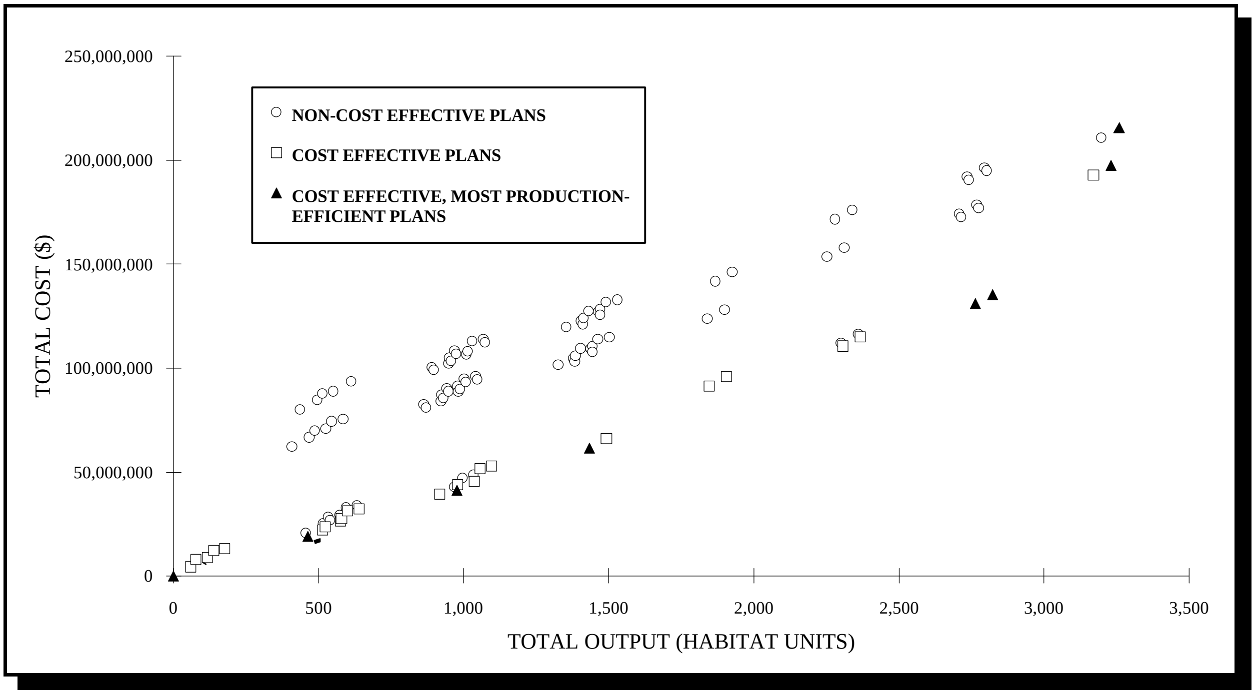


Figure 3-7 All Plans

some cases, the economic and environmental models used to estimate the effects of environmental restoration plans are not capable of capturing the full range of such effects. The models may be incapable of accounting for all considerations that impact upon the decision process. For example, concerns about endangered species, support by a local sponsor or other interest group, cost sharing arrangements, and other factors may lead to the continuing consideration and selection of solutions that may not be the most cost effective, or that may incur substantial incremental costs. Planners should make decision makers aware of these situations, and present any reasons that may support a decision to pursue an otherwise less efficient or effective solution. If decision makers select a solution that the analyses show is not the most cost effective or incrementally justified, then the reasons for such a selection should be clearly explained in the supporting documentation as well as the potential implications for cost sharing.

Even if selecting from among the most production efficient, cost effective plans, the decision process may be facilitated by providing concise, easily visualized information as to other considerations or unintended effects of plans that were not accounted for in cost and output estimates, or that merit special attention. For example, Figure 3-8 is a modified version of Exhibit Step 9B. In this figure, the incremental bar chart showing the intended effects (habitat units) is accompanied by a table of "other" or "unintended" effects of plans that might impact the decision process.

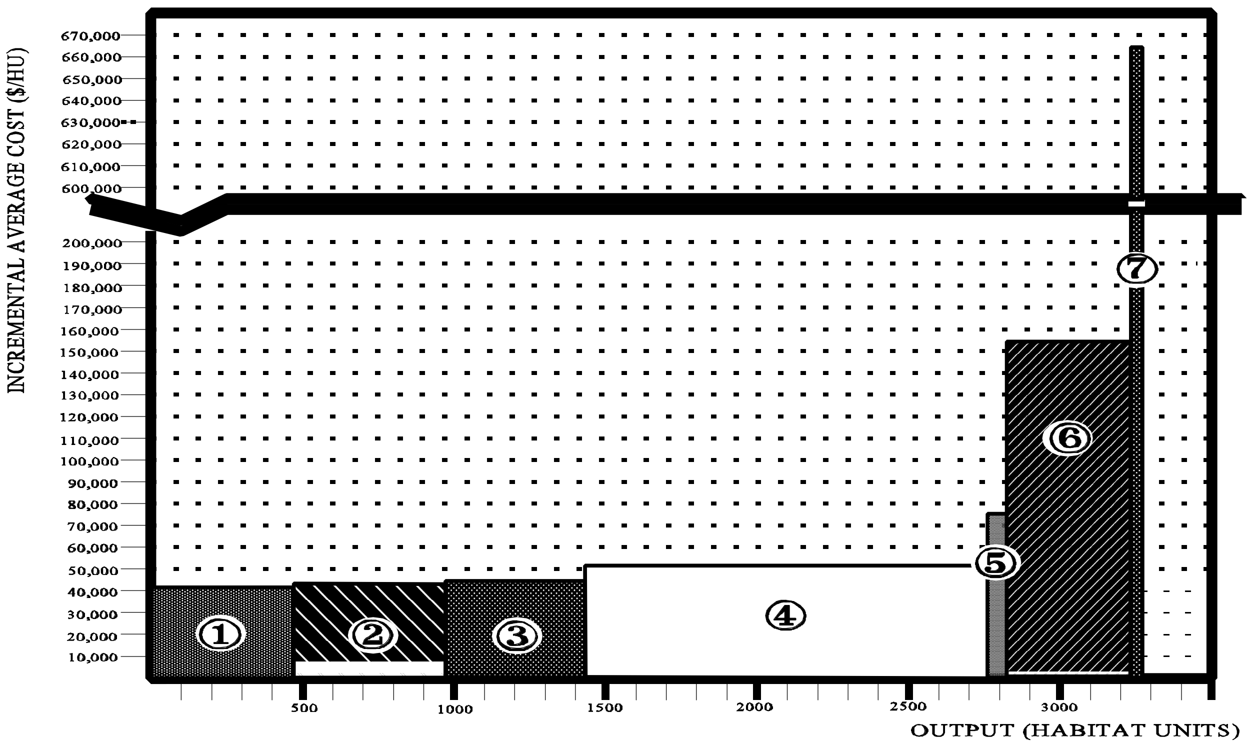
The table below the graph shows that as we increase output, our "intended" effect, there are other impacts or considerations that vary. For example, as habitat units increase, we can see that flood reduction benefits currently being provided are negatively affected ("opportunity costs" are incurred). Also, we can see that as we increase habitat units, real estate ownership may become increasingly important. Similarly, we can see that different plans have varying effects on a nearby cultural resource (historic battlefield), and also have varying effects on habitat for another species (in this case, a hypothetical species the ferocies).

While this manual provides a variety of examples of graphical formats for presenting data to support cost effectiveness and incremental cost analyses, there are many additional formats that may prove effective for communicating information to facilitate decision making. Just as each planning study has different characteristics, different graphical formats may prove effective in facilitating decision making and "telling the story" for different studies. Practitioners are encouraged to explore different methods in finding the most appropriate graphics formats for facilitating decision making and describing their planning studies.

COST EFFECTIVENESS AND INCREMENTAL COST ANALYSES - SUMMARY

The previous two examples in this chapter dealt first with the formulation of alternative plans and then with the evaluation of those plans utilizing the economic tools of cost effectiveness and incremental cost analyses. The first example demonstrated the evaluation of the relative production efficiencies of individual management measures under consideration. These relative production efficiencies were used as a guide for the formulation of cost effective alternative plans with increasing incremental costs per unit.

The second example demonstrated the application of the *Nine EASY Steps* process for plan formulation and evaluation. This process takes a list of management measures under consideration and then formulates every


670,000
660,000
650,000
640,000
630,000
620,000
610,000
600,000
200,000
190,000
180,000
170,000
160,000
150,000
140,000
130,000
120,000
110,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
INCREMENTAL AVERAGE COST ($/HU)
1
2
3
4
5
6
7
500
1000
1500
2000
2500
3000
OUTPUT (HABITAT UNITS)

	①	②	③	④	⑤	⑥	⑦
FLOOD CONTROL OPPORTUNITY COSTS ($10,000)	[-$20]	[-$30]	[-$30]	[-$30]	[-$30]	[-$40]	[-$50]
LAND OWNERSHIP	sponsor	sponsor and state	sponsor and state	sponsor and state	sponsor and state	sponsor state and private	sponsor state and private
BLUE RIVER BATTLEFIELD HISTORIC SITE	0	0	+	++	+++	++	+
FEROCIES HABITAT (% OF TOTAL IN BASIN)	0.00%	-1.45%	-2.90%	-4.55%	-6.21%	-6.19%	-6.17%

Figure 3-8 Intended and Unintended Effects of Cost Effective, Most Production Efficient Plans

possible combination (plan). Then cost effectiveness analysis was applied to screen out non-cost effective plans before conducting incremental cost analysis. Often, cost effective plans will exhibit fluctuating incremental cost per unit as we increase project scale. Sometimes, these fluctuating costs can make the selection of project scale unclear. To “illuminate” this project scale decision, we introduced an additional analytical technique to identify a range of cost effective plans with increasing incremental cost per unit as we increase project scale. While both of these previous techniques were concerned with both plan formulation *and* evaluation, sometimes staff with responsibility for plan evaluation may not be involved in plan formulation. Or, in some cases, a non-comprehensive list of alternative plans may be formulated based upon other criteria than we have previously identified; for example, physical or engineering considerations combined with professional judgment. This may often be the case, for example, in the identification of different scales of individual management measures. To conduct cost effectiveness and incremental cost analyses in such cases, only Steps 4 through 9 of the *Nine EASY Steps* procedure outlined in this Chapter need to be applied. These steps will identify the range of least cost plans for every output level; identify the full range of cost effective plans under consideration; conduct incremental cost analysis on those cost effective plans to identify the relationship of changes in output to changes in cost as project scale increases; and, if necessary, can smooth out “fluctuating” or “lumpy” incremental cost data to assist in the selection of project scale.

The plan formulation and evaluation framework presented in this manual is intended to provide information to lead to better informed decisions regarding the restoration or mitigation of environmental resources. While the evaluation tools of cost effectiveness and incremental cost analyses do not provide a discrete decision rule for plan selection, they do provide the types information to support such decisions. The Appendix to this manual provides detailed instructions in the use of automated procedures to conduct the analytical calculations required of both the plan formulation and evaluation procedures in the *Nine EASY Steps* methodology. By performing the potentially large number of routine calculations, the automated procedures simplify the formulation and evaluation requirements on the planner, facilitating the examination of a wide range of alternative plans.

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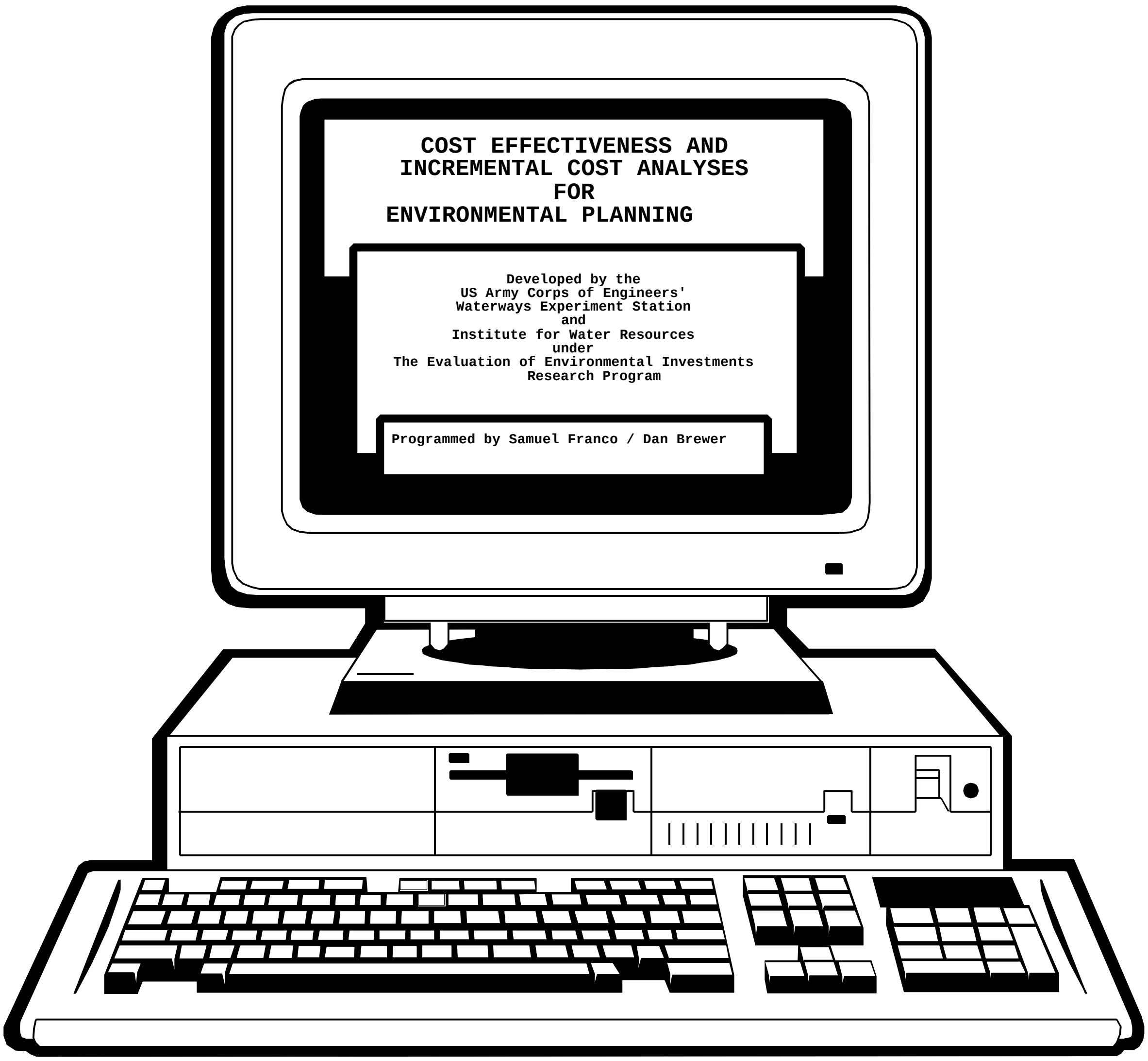


Instructions for Use of Automated Procedures for Conducting Cost Effectiveness and Incremental Cost Analyses

FOREWORD

The following instructions accompany the software program, ***Automated Procedures for Conducting Cost Effectiveness and Incremental Cost Analyses (Beta Version 2.0)***. As with the rest of this "interim" manual, we plan to refine and supplement both the Automated Procedures and their instructions based upon findings from future technology transfer workshops and field applications. Users of the manual and the Automated Procedures are provided an opportunity to voice their comments by filling out a questionnaire found at the rear of the text.

As is often the case with software in development, it is difficult to publish instructions that are 100% current with on-going program refinements. In an effort to get environmental plan evaluation tools to the field as quickly as possible, the following instructions were published concurrent with on-going software refinements. As such, there may be some minor inconsistencies in screen reproductions found in the instructions and actual screens viewed when running the program. These inconsistencies should amount to some minor differences in text, or text placement and should not impact the reader's ability to follow the instructions and apply the program. Any significant changes in program will be addressed in a "READ ME" file to be included on the programs installation diskette. All user's should read this file before installing and running the Automated Procedures. The "final" version of this manual should correct any such inconsistencies and address any other software refinements.

OBTAINING SOFTWARE

If you are interested in receiving a copy of the Automated Procedures, contact either Samuel Franco (601/634-4205) or Tracy Trichell (601/634-2195) of the Waterways Experiment Station, Environmental Laboratory. For toll-free dialing, call 1-800-LAB-6WES and enter the last-four-digit-extension of the appropriate number.

TABLE OF CONTENTS:

PROGRAM DESCRIPTION

Program Purpose

The following instructions accompany the software program ***Automated Procedures for Conducting Cost Effectiveness and Incremental Cost Analyses (Beta Version 2.0).*** The purpose of the *Automated Procedures* is to carry out the mechanical calculations necessary to conduct cost effectiveness and incremental cost analyses for the evaluation of environmental restoration or mitigation plans. The Automated Procedures produce a series of reports, in both matrix and graphical formats, which can be used for documenting the analyses and supporting decisions based upon their results.

While principally designed for assisting with plan evaluation, the Automated Procedures can also be useful for assisting in plan formulation. The Automated Procedures have the capability of generating plans by taking a discrete number of management measures and generating a comprehensive list of the alternative plans that could be derived by all possible combinations of those management measures.

The Automated Procedures are intended to reduce the analytical burden of environmental plan evaluation and thereby facilitate the formulation and evaluation of a diverse range of alternative plans. While the Automated Procedures are useful for assisting with plan formulation and evaluation, they are not a "black-box" that processes data and then outputs a recommended plan.

Rather, the Automated Procedures take data, regarding either different management measures, or combinations thereof (plans), and by performing a series of routine mathematical calculations, provide the types of information which can assist in the selection of the most desirable management action or solution.

Hardware Requirements

The Automated Procedures have been tested and should work on personal computers with either a 286, 386, or 486 processor. Program runtime will be longer on the lower numbered processors. Program runtime could require up to several days for large input files. The program requires at least 4 megabytes of RAM. Hard drive space required for data storage varies depending on the scope of input file. Large input files may require over 20 megabytes of hard disc storage space for large data files (*See next section on "Data Requirements" for further discussion of the relationship between size of input file and output files)*. The Automated Procedures are compatible with HP Laser Jet Printers.

Data Requirements

To conduct cost effectiveness and incremental cost analyses using the Automated Procedures, three types of data are required. First, a list of specific *management measures*, or alternatively, a list of combinations of management measures, called *plans,* is required. For a discussion of management measures and plans, see the sections on "Terminology" and "Plan Formulation" in Chapter Three of the manual's main text. The remaining two types of required data are the *cost* and *output* estimates associated with each management measure or plan.

Cost estimates for different management measures or plans in a single study need to be treated consistently. Discounting is to be used to convert future monetary values to present values. All plans under consideration should use the same discount rate. For more information, see the section on "Cost and Output Estimation" in Chapter Three.

Similarly, output estimates for different management actions or plans need to be treated consistently. Results may be more meaningful if the environmental effects of alternative management measures or plans are estimated using the same environmental models and are measured in the same units. Output estimates may be measured in acres, habitat units, population counts, or any other cardinal units of measurement; but typically should be consistent across plans.

It is equally important that economic effects and environmental effects be treated consistently. If costs are annualized, then output estimates must also be annualized for consistency in analysis.

The number of different management measures that can be input in an application of the Automated Procedures has been limited to 15. Each of these management measures can have up to 10 different scales. For example, if a management measure is to construct a levee, we could enter up to 10 different scales of levee height.

The limitations on input data are necessary to maintain the integrity of the Automated Procedures' results and to try and avoid excessively long runtimes. Memory overloads and runtimes in excess of several days could result without the limits of management measures and their respective scales.

Potential problems with memory and excessive runtimes stem from the plan formulation components of the program. If we enter 10 different management measures and 10 scales (including a no-action "scale") of each, using the formula in Figure 3-4 of Chapter 3, there are 10 billion possible alternative plans. Building and storing the matrix containing these solutions and calculating the cost and output of each takes time and disk space.

The potential memory and runtime problems stress the need for using reason when deciding the number of management measures; and similarly, the number of scales of each measure to be considered. After gaining some experience with the application of the Automated Procedures, methods will become apparent for handling more management measures or more scales of management measures than the program will allow in a single run. For example, an application can be broken into components and separate runs can then be conducted.

In a 1994 restoration study by St. Louis District, *Calhoun Point Rehabilitation and Enhancement Project*, the *Nine EASY Steps* procedure, presented in Chapter Three of this manual, was utilized for conducting cost effectiveness and incremental cost analyses. This *Nine EASY Steps* procedure also served as the blueprint for the programming of the Automated Procedures. Because the Automated Procedures were still in development, St. Louis District analysts programmed spreadsheets to carry out the calculations necessary for the analyses.

In the study, 15 different management measures were considered, one of which had sixteen different scales. Analysts were faced with over 327 million potential plans. Instead of evaluating all of those potential plans, the analysts performed cost effectiveness analysis on each management measure separately, removing scales found to be either inefficient or ineffective in production from further consideration.

This process of eliminating non cost effective management measures before combining them into plans resulted in a reduction from the potential 327 million possible plans to 25,920 possible plans for initial consideration. Subsequent cost effectiveness screening of those plans left 106 solutions for incremental cost analysis. Such creative thinking may be required in performing the analyses on complex planning applications. Chapter Three of this manual provides tools which can facilitate such creative thinking.

The Automated Procedures are intended to reduce the analytical burden of analysts; for example, in the programming of spreadsheets. With their computer performing most of the time-consuming calculations that can be required by cost effectiveness and incremental analysis, planners should have more time to look at a broad range of alternative plans and evaluate their costs and outputs.

Much of the remainder of these instructions will step through the creation of a new file, input of data required for the analyses, production of reports, and editing of input data using an example application.

While the text and accompanying reproductions of computer screens should provide adequate instruction in the use of the Automated Procedures, readers are encouraged to work through the example at their computer for a "hands-on" introduction to the program. First, it will be necessary to install the Automated Procedures on your computer's hard drive.

SOFTWARE INSTALLATION

To install the Automated Procedures on your computer, first create a directory on your hard drive into which you will copy the files from the installation diskette. For this example, we will create a directory called "CEA" by typing at the C:\> prompt: "MD CEA". After creating the CEA directory, we will move into that directory by typing, "CD CEA" at the C:\> prompt.

From within the CEA directory, view the "READ.ME" file for any program updates or additional instructions. Then, install the program by typing "INSTALL at the C:\CEA> prompt.

GETTING STARTED

Executing Program

To execute the program from within the CEA subdirectory, at the C:\CEA> prompt, type CEA. After entering this command, the following Title Screen will appear:

```
COST EFFECTIVENESS AND
INCREMENTAL COST ANALYSES
FOR
ENVIRONMENTAL PLANNING

Developed by the
US Army Corps of Engineers'
Waterways Experiment Station
and
Institute for Water Resources
under
The Evaluation of Environmental Investments
Research Program

Programmed by Samuel Franco / Dan Brewer
```

File Management Menu

From the Title Screen, press any key to advance to the next screen, the File Management Menu. The File Management Menu offers six options: Create a New File; Retrieve a Saved File; Copy a File; Delete a File; Rename a File; and Quit to DOS. A discussion of each menu selection follows.

Create a New File

Select this menu item to create a new file containing the input data required for conducting cost effectiveness and incremental cost analysis for environmental plan evaluation. Upon selecting this item, the File Name Entry Screen will appear.

```
FILE MANAGEMENT MENU

Create a New File
Retrieve a Saved File
Copy a File
Delete a File
Rename a File
Quit to DOS
```

Retrieve a Saved File

Select this menu item either to: a) view or print output reports from a previous application of the program; or b) edit the input data from a previous application and generate new output files. Upon selecting this item, the Retrieve File Menu will appear.

The Retrieve File Menu allows the user to view a list of the files created in previous applications of the program. After selecting a file to retrieve, the user will have two options: Edit Matrices; and View Matrices. If selecting the Edit Matrices menu item, the Management Measure Entry Screen will appear.

If selecting the View Matrices menu item, the Report Management Menu will appear. Further instructions for proceeding from the Report Management Menu are found in the section "Report Management Menu".

Copy a File

Select this menu selection to copy an existing file to another diskette or directory. Upon selecting this menu item, the program will list the files from previous applications. The user would then select a file to copy. The program will then prompt the user to input the desired name for, and destination of, the copy.

Delete a File

Select this menu item to delete a file created in a previous run of the program. Upon selecting this menu item, the program will list the files from previous applications. The user would then select the file to be deleted.

Rename a File

Select this menu item to rename an existing file from a previous run. Upon selecting this menu item, the program will list the files from previous applications. The user would then select the file to be renamed and be prompted to enter its new name.

Quit to Dos

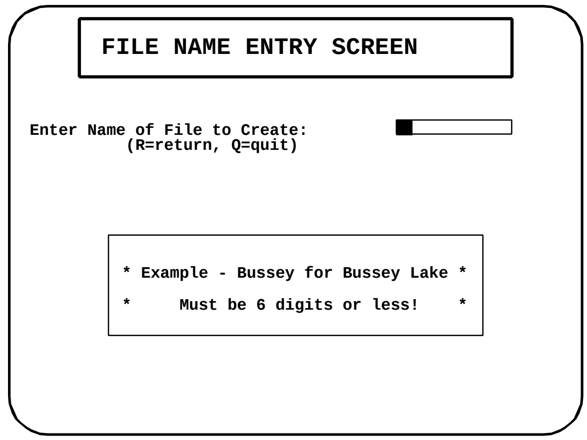
Select this menu item to exit the program and return to DOS. Whenever Quit to DOS is selected all files are automatically saved.

DATA INPUT / DATA EDITING SCREENS

The following screens appear for both entering and editing data in either a new or existing data set, respectively. For the purpose of instruction, first we will step through the creation of a new file and the production of reports. Later, we will show how to edit an existing file.

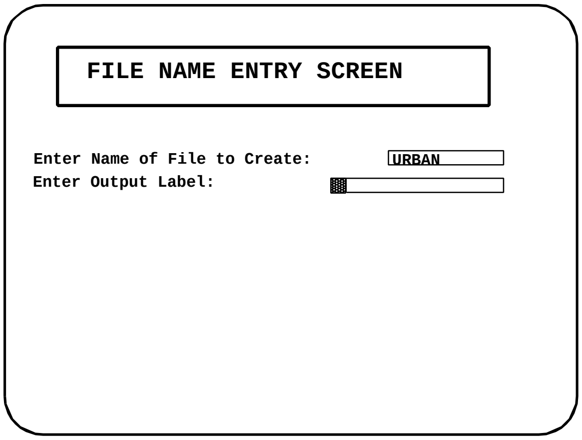
File Name Entry Screen

Upon selecting the Create a New File menu item from the File Management Menu, the File Name Entry Screen will appear. The File Name Entry Screen will prompt you to enter a name for the file you are creating. The program will use this file-name in combination with different three letter extensions to save input and output files for this run of the program.



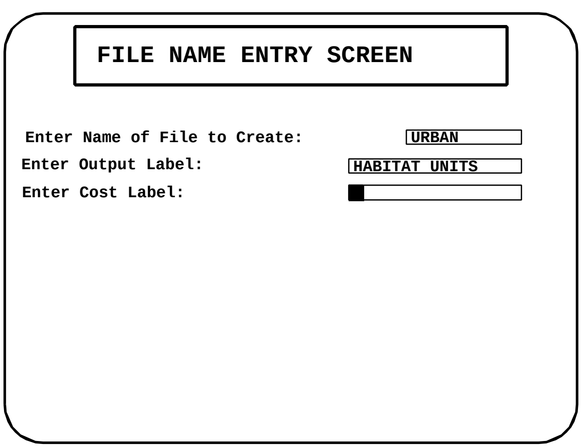
To enter a file-name, type in any string of 2 to 6 characters, (the first character must be a letter), and then strike the enter key. Entering the single letter "R" will return you to the File Management Menu. Entering the letter "Q" will exit the program and return to DOS.

Let's begin our example exercise by typing in the file-name "URBAN", followed by the enter key. This name is representative of the regional urban wetlands restoration example in Chapter Three that provides the data for our example application.

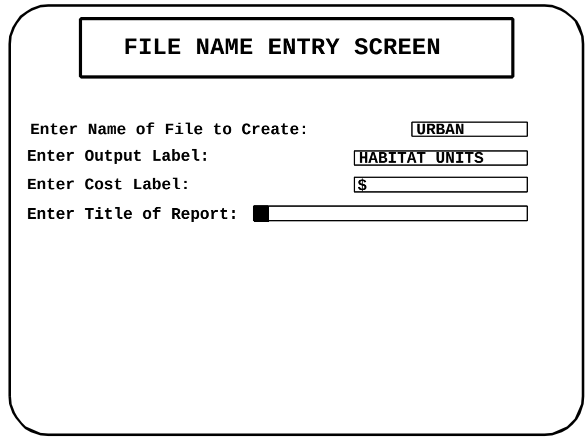


After entering the file-name “URBAN”, a prompt will appear asking you to enter an Output Label. Output labels must be no longer than 30 characters. Since the output in this exercise from Chapter Three was measured in habitat units, enter “HABITAT UNITS” at the prompt. Examples of other typical output labels might include: “ACRES”, “POPULATION”, “HABITAT UNITS X 100", or “AVERAGE ANNUAL HABITAT UNITS”.

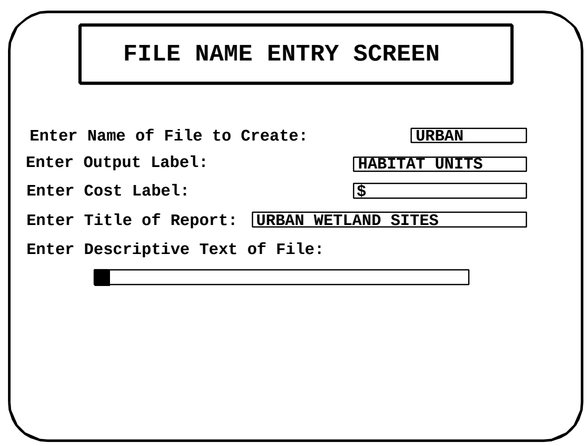
Next, you will be prompted to enter a Cost Label. Like output labels, cost labels must be less than or equal to 30 characters. At this prompt we will enter “$”. Examples of other typical cost labels might include: “AVERAGE ANNUAL $” OR “$ X 100,000". The entries for Output and Cost Labels will be used to label reports to be generated by the Automated Procedures.



Next, you will be prompted to enter a report title. This title will appear as the heading on all reports produced by the Automated Procedures. This title can be up to 30 characters long.



In our example application, we will enter the report title “URBAN WETLAND SITES” because we will be using the automated procedures to evaluate a number of sites proposed for restoration. Typically, the report heading might include the name of the study; for example, “BUSSEY LAKE”.



Next, you will be prompted to enter Descriptive Text for the purposes of describing this application. You are provided with 3 lines of 40 or less characters each. Text does not scroll from one line to the next. Rather, when you have entered as many characters as will fit on one line, strike the enter key to move to the next line.

The descriptive text is useful, for example, to describe differences in input data for different application runs for a single planning study (for example, if you are conducting a sensitivity analysis).

In our example application, we will enter the following descriptive text on the first line: "URBAN WETLANDS RESTORATION STUDY". Striking the enter key will move us down to the next line where we will type "EVALUATION OF PROPOSED SITES". Again, after striking the enter key, we move to the third line where we will enter "DATE OF APPLICATION" and strike the enter key.

While this descriptive text does not appear on any reports, it is useful for describing the current application for future reference.

```
FILE NAME ENTRY SCREEN

Enter Name of File to Create:        URBAN
Enter Output Label:              HABITAT UNITS
Enter Cost Label:                $
Enter Title of Report:  URBAN WETLANDS SITES
Enter Descriptive Text of File:
      URBAN WETLANDS RESTORATION STUDY
      EVALUATION OF PROPOSED SITES
      DATE OF APPLICATION

      Is all this information correct? Y/N   Y
```

Next, you will be asked if the information entered in the File Name Entry Screen is correct. You will be automatically prompted with a "Y", representing "YES". If you would like to edit or change any of the information on the screen, strike and enter the "N" key.

For example, let's say that we decided we would rather enter cost values in multiples of $10,000. Now, we need to change the cost label. To make this change, strike the "N" key and then the enter key. Now the cursor will move back to the Name of File entry line.

```
FILE NAME ENTRY SCREEN

Enter Name of File to Create:        URBAN
Enter Output Units Label:        HABITAT UNITS
Enter Cost Label:                $ X 100000
```

Since we don't want to change this line, strike the enter key. This will move the cursor to the Output Label entry line. Again strike the enter key to move down to the Cost Label entry line. Now, using the arrow keys we can move to the right of the "$" and type "X 100000" and strike the enter key.This will move the cursor down to the Title of Report entry line. Since no changes are to be made to the Title of Report entry or to any lines of the Descriptive Text entry, strike the enter key until you are again asked "Is all this information correct?" Since the prompt automatically reads "Y", strike the enter key if all information has been entered correctly. Upon, entering a "Y", you will be prompted to enter either a "P" to proceed, "R" to return to the previous screen, or a "Q" to quit to DOS. Enter a "P" now to advance to the Management Measure Entry Screen.

Management Measure Entry Screen

The Management Measure Entry Screen will allow entry of up to 15 different management measures (more on "management measures" in the section, "Terminology", in Chapter 3).

In our example application, we will be conducting a regional evaluation of the potential restoration of five independent wetland sites: Sites A, B, C, D, and

E. We will consider the choice to restore each site as a management measure.

Sites A, C and E each have only one restoration plan under consideration. We are assuming that an evaluation of alternative solutions for each of these sites has already been conducted and a recommended plan at each site has been selected for consideration in this regional analysis.

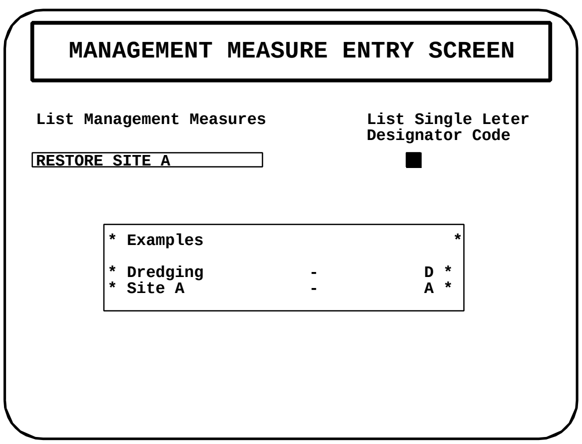
At Site B, we will be looking at 4 alternative scales of restoration. All “scales” within any one measure are treated as mutually exclusive by the Automated Procedures. In this case, each successive scale employs the same restoration measures, but to increasing acreage. As such, these scales will be considered as mutually exclusive. At Site D, we will be evaluating two alternative solutions, one involving the installation of a culvert, the other involving the installation of two channels. We will assume that these two plans at Site D are mutually exclusive. Therefore, we can treat these two plans as “scales” of Site D.

It is useful to organize the input data required for an application of the Automated Procedures in a table format similar to that in Table A-1. Table A-1 contains a list of the management measures under consideration in this regional analysis. Where applicable, alternative scales of a management measure are listed. The cost and the output of each management measure scale is also contained in the table.

Now, we must input the data from Table A-1 into the program. First, we will enter the management measures through the Management Measure Entry Screen. The first management measure in Table A-1 is to restore Site A.

MANAGEMENT MEASURE:	SCALES:	COST ($ X 100,000):	OUTPUT: (Habitat Units)
RESTORE SITE A	1	$205.00	456
RESTORE SITE B	1(200 ACRES)	$78.00	78
	2(400 ACRES)	$88.48	117
	3(600 ACRES)	$221.00	514
	4(800 ACRES)	$915.00	1845
RESTORE SITE C	1	$190.00	462
RESTORE SITE D	1(CULVERT)	$620.00	408
	2(CHANNELS)	$800.00	435
RESTORE SITE E	1	$45.00	60

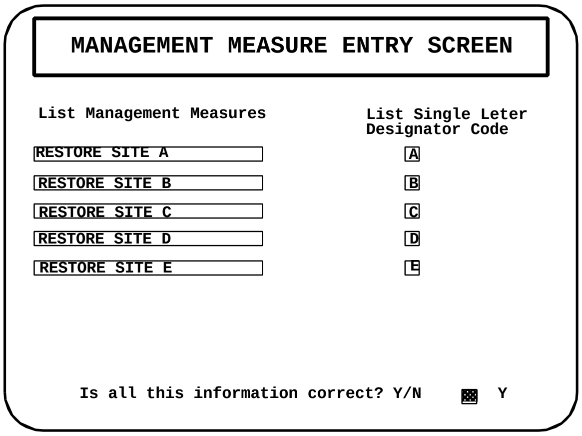
Table A-1 Input Data for Automated Procedures Example Application



Therefore, at the List Management Measures prompt, enter “RESTORE SITE A”. After striking the enter key, the prompt will ask you for a Single Letter Designator Code. This code is what the Automated Procedures will use to signify the management measure just entered.

It is useful to select a Single Letter Designator Code that is indicative, in some way, of the management measure; for example, the first letter of the management measure may be a good designator code. Designator Codes will be printed on reports as opposed to full names of management measures.

In our example application, we will enter “A” as the Single letter Designator Code for Site A. After striking the enter key, you will be prompted to enter the next management measure (“RESTORE SITE B”). Similarly, after entering the next management measure you will be prompted to enter its Single Letter Designator Code (“B”). Continue this process, entering “RESTORE SITE C” and “C”; “RESTORE SITE D” and “D”; and RESTORE SITE E” and “E” for the remaining three management measures and designator codes, respectively.



After entering the Single Letter Designator Code for Site E, you will be prompted to enter the next management measure. Since we have no more management measures, do not enter any characters. Rather, strike the enter key on a blank field to tell the Automated Procedures that you are finished inputting management measures.

You will now be asked if you are finished entering management measures. If you realized that you had additional management measures to add, you would enter "N" and would then be prompted to enter another management measure and designator code. When you were finished you would again strike the enter key on a blank field to tell the Automated Procedures you had no additional management measure to enter.

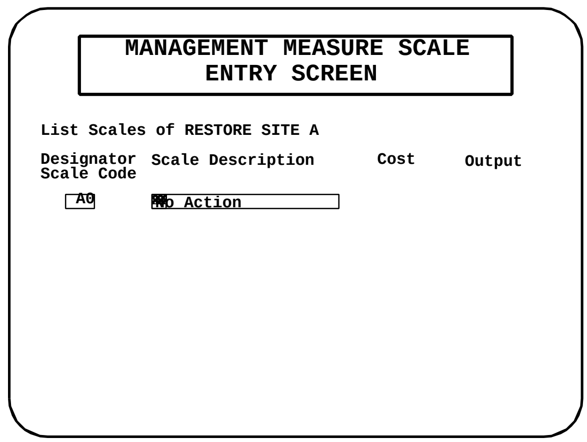
Since we have no additional management measures to enter, we are ready to proceed to the next data entry screen. The Automated Procedures, when asking if you are finished inputting management measures will automatically prompt you with a "Y".

The Automated Procedures will then ask you if all the data entered on the Management Measure Entry Screen is correct. If you wish to edit any of this data, follow the same editing procedures as on the File Name Entry Screen. If the information does not require editing, enter "Y" at the prompt. At the next prompt, enter a "P" to proceed to the Management Measure Scale Entry Screen.

Management Measure Scale Entry Screen

The Management Measure Scale Entry Screen allows you to enter up to 10 different scales for each management measure entered in the Management Measure Entry Screen. The first of the 10 scales for every management measure will be the no-action scale. A no-action scale and at least one other scale must be entered for each management measure.

Each management measure will have its own management measure entry screen. For example, in our example application, we entered 5 management measures so we will pass through five management measure scale entry screens.



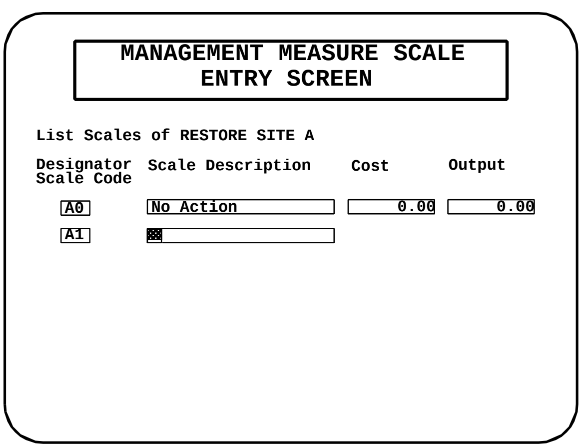
The first management measure scale entry screen will be for the first management measure entered; in our example application, Site A. Note the instructions on this screen to "List Scales of RESTORE SITE A". The first data field on this screen is the Designator Scale Code. This data will be automatically generated by the Automated Procedures and cannot be edited.

The Designator Scale Code is the Single Letter Designator Code we entered in the Management Measure Entry followed by an index. The index will range from 0 to 9 and if a tenth scale is entered it will be designated by the scale code "A"; for example, scale code AA would indicate the tenth scale of the measures corresponding to designator code “A”. An index of 0, (for example, A0), will always signify the no-action scale for each management measure. The designator scale code will appear in reports as opposed to the next data field, Scale Descriptive Text.

The second data field contains Scale Descriptive Text. The Automated Procedures will automatically place the text “No Action” in the first descriptive text field for each management measure. This text can be edited if desired. In our example application, we want to keep this text, so we will strike the enter key. Now the cursor moves to the data entry field for Cost.

The Automated Procedures automatically place a value of 0.00 in the cost data entry field for the no-action scale. To keep this value strike the enter key. This field is editable if there is a cost associated with the no-action plan. In our example application, the no-action plan has no cost and so we will strike enter.

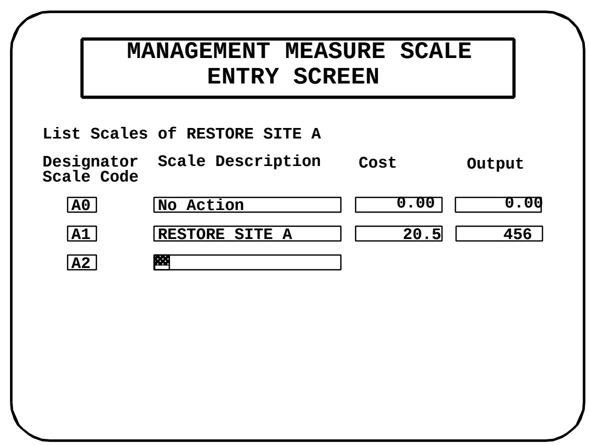
The cursor will now move to the Output data entry field. Like the Cost field, the output field will automatically have a value of 0.00 for the no-action scale. We will keep this value by striking the enter key.



Now we are prompted to enter descriptive text for Scale A1. This descriptive text can be useful, for example, in describing the physical differentiation of each scale from the other scales. Because we only have one scale (other than the no-action scale) for Site A, we can simple enter “RESTORE SITE A”. After striking the enter key, we will be prompted to enter the cost for Scale A1. From Table A-1, the cost is $20,500,000. Since we are entering cost data in multiples of $100,000, we will enter “205" in this field. Do not enter dollar signs or commas in the cost field, the Automated Procedures cannot read these characters.

After making our cost entry, we will be prompted to enter the output for Scale A1. From Table A-1, this value is 456 habitat units. We will enter “456" in this field. We have already entered the label habitat units in the File Name Entry Screen.

After making our output entry, we will be prompted to enter descriptive text for Scale A2.



Since we only have Scales A0 and A1, strike the enter key in this empty field to tell the Automated Procedures that there are no additional scales for Site A. The automated procedures will then ask “Are you finished inputting management measure scales?”. Had we more scales to enter, we would enter “N”, and the cursor would return to the scale description field for scale A2.

Since, in this example application, we have no more scales to enter for management measure “Restore Site A”, we will enter “Y” at this prompt. The

Automated Procedures will now ask if the all the data entered in the Management Measure Scale Entry Screen for Site A is correct. If any data requires editing, the editing procedures are the same as described in the instructions for the File Name Entry Screen.

If no data requires editing, enter a “Y” at this prompt. At the next prompt, enter “P” to proceed to the Management Measure Scale Entry Screen for the management measure “Restore Site B”.

MANAGEMENT MEASURE SCALE ENTRY SCREEN

List Scales of RESTORE SITE B

Designator Scale Code	Scale Description	Cost	Output
B0	No Action		

The procedures for filling each remaining Management Measure Scale Entry Screen with the appropriate data are the same as described for Site A. Site B will require the entry of four management measure scales in addition to the no action scale. Similarly, Site D will require the entry of two scales in addition to its no action scale. If you are working through this example, enter the data for management measure scales for Sites B, C, D and E, found in Table A-1.

Reproductions of the completed Management Measure Scale Entry Screen for each of the remaining management measures follow.

MANAGEMENT MEASURE SCALE ENTRY SCREEN

List Scales of RESTORE SITE B

Designator Scale Code	Scale Description	Cost	Output
B1	No Action	0.00	0.00
B1	RESTORE 200 ACRES	78	78
B2	RESTORE 400 ACRES	88.48	117
B3	RESTORE 600 ACRES	221	514
B4	RESTORE 800 ACRES	915	1845

MANAGEMENT MEASURE SCALE ENTRY SCREEN

List Scales of RESTORE SITE C

Designator Scale Code	Scale Description	Cost	Output
C0	No Action	0.00	0.00
C1	RESTORE SITE C	190	462

MANAGEMENT MEASURE SCALE ENTRY SCREEN

List Scales of RESTORE SITE D

Designator Scale Code	Scale Description	Cost	Output
D0	No Action	0.00	0.00
D1	SITE D (CULVERT)	620	408
D2	SITE D (CHANNELS)	800	435

MANAGEMENT MEASURE SCALE ENTRY SCREEN

List Scales of RESTORE SITE E

Designator Scale Code	Scale Description	Cost	Output
E0	No Action	0.00	0.00
E1	RESTORE SITE E	45	60

Building Management Measures Matrix Screen

After entering the data for the last Site, Site E, the Building Management Measure Matrix Screen will appear.

BUILDING MANAGEMENT MEASURE MATRIX

The Building Management Measure Matrix Screen will remain until the Automated Procedures have completed deriving all combinations of management measures. Numbers will scroll through the box in the center of this screen to show that the computer is working. The time required for building the matrix will vary depending on computer hardware and number of management measures and their respective scales being combined.

Combinable Management Measure Screen

The Combinable Management Measure Screen asks the user to identify which management measures are combinable with which others. A discussion of combinability can be found in the section, "Combinability Relationships", in Chapter Three. In our example application, all management measures are combinable. So we can enter "Y" at the prompt asking if all measures are combinable.

COMBINABLE MANAGEMENT MEASURE SCREEN

MANAGEMENT MEASURE:	DESIGNATOR/NON-COMBINABLES
RESTORE SITE A	A
RESTORE SITE B	B
RESTORE SITE C	C
RESTORE SITE D	D
RESTORE SITE E	E

Are all the above Management Measures Combinable? (Y/N)

If management measures were not combinable, we would enter a "N" at the prompt.

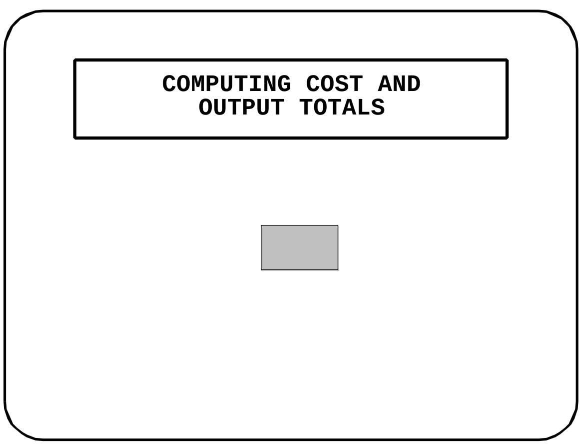
For example, if Sites A, B and C were not combinable, we would enter a "N" at the above prompt. The program would then direct us to "Enter non-combinable management measure designator code (blank to quit)". We could respond by entering either an "A", "B" or "C".
Assume we entered "A". Next, the program would direct that we "Enter management measure codes not combinable with above (blank to quit)". We would type "B" followed by the enter key and then "C" followed by the enter key. To tell the program that there are no other measures non combinable with "A", we enter on a blank field. The program would then show letters "B" and "C" beside "A" on the screen to show the relationships entered. Next, it would prompt us to "Enter non-combinable management measure designator code (blank to quit)". Since there are no other non combinable relationships, we would enter a blank field. The program would then advance to the Dependent Management Measure Screen.

Dependent Management Measure Screen

This screen asks us to enter all dependency relationships among measures into the program. A discussion of dependence can be found in the section, "Dependency Relationships" in Chapter Three. The entry of dependency relationships through the Dependent Management Measure Screen utilizes the same technique described for entering combinability relationships in the section preceding this. After entering all dependency relationships the program advances to the Computing Cost and Output Totals Screen.

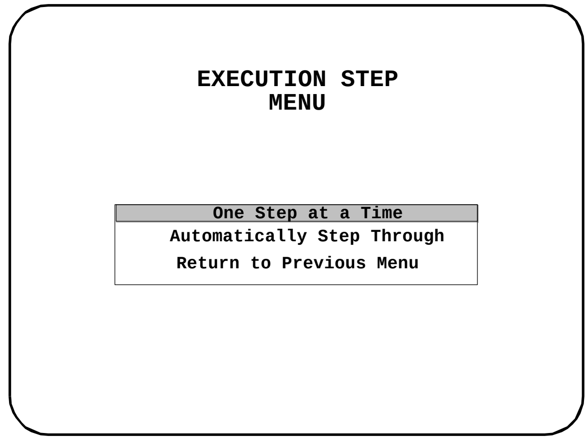
Computing Cost and Output Totals Screen

The Computing Cost and Output Totals Screen is similar to the Building Management Measures Matrix Screen in that it appears while the Automated Procedures are adding up the cost and output totals for each combination of management measures. Numbers will scroll through the box in the center of the screen



showing that the computer is processing data. The time required for making these computations will vary and is dependent upon computer hardware, the size of the data entry file, and the number of combinable management measures. This computational process has the potential to take up to several days for large input files.

Execution Step Menu



After the program has finished computing the cost and output for all plans, the Execution Step Menu will appear. The Execution Step Menu offers three choices: One Step at a Time; Automatically Step Through; and Return to Previous Menu.

"One Step at a Time" Menu Selection

The "One Step at a Time" mode steps through each screening and computing phase in the *Nine EASY Step* process found in Chapter Three. At the end of each phase, a menu will appear offering the user an opportunity to view and print a matrix of the remaining plans and their respective data, as well as a graph plotting the cost and output of those plans.

"Automatically Step Through" Menu Selection

The "Automatically Step Through" mode automatically advances through each screening and computational phases in the *Nine EASY Step* process. Then, when all analytical steps are completed, the Report Management Menu will appear allowing the user to view all matrices and graphs that were produced.

"Return to Previous Menu" Menu Selection

The "Return to Previous Menu" menu selection will return the user to the Dependent Management Measure Screen.

One Step at a Time Data Processing Mode

Upon selection of the "One Step at a Time" menu item on the Execution Step Menu, the Combinations of Output and Cost Menu will appear. This menu offers several options: To View/Edit Matrix, to Print Matrix, to Proceed with Analysis, and to Return to Previous Menu.

Selection of the View/Edit menu item allows the user to view all combinations of measures and their respective cost and output. **This is the only place within the Automated Procedures where the user can edit the cost and output estimates for combinations to address the issue of *non-additive cost and output estimates.*** For a discussion of non-additive cost and output estimates, see the section, Additive Cost and Output Estimates, in Chapter Three.

Selection of the Print Matrix menu item will send a copy of this matrix to the printer. Use caution when printing - some output files may be thousands of pages long and it may not be desirable to print this file. Hitting the "ctrl" and "page down" keys simultaneously while in the view/edit matrix mode will advance the cursor to the last record in the file. This will show how many records will be printed; approximately 50 records can be printed per page of output.

Selecting the Proceed with Analysis menu item will advance the program to the Combinations Sorted by Output and Cost menu.

Selecting the "Return to Previous Menu" menu item will return to the Execution Step menu.

Combinations Sorted by Output and Cost Menu

The Combinations Sorted by Output and Cost Menu offers several options.

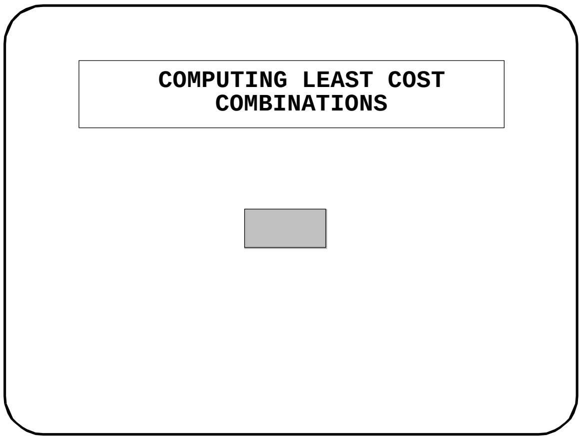
```
COMBINATIONS SORTED BY
   OUTPUT AND COST

    Print Matrix
    View Matrix
 View Graph of Matrix
 Print Graph of Matrix
 Proceed with Analysis
```

The "Print Matrix" menu selection allows the user to send a copy of all combinations of management measures (plans) with their cost and output to the printer. The "View Matrix" menu selection allows the user to scroll through the matrix of all combinations of management measures (plans) with their cost and output on their monitor.

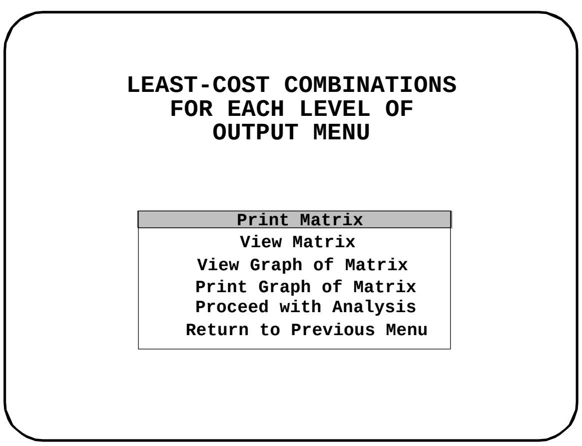
The "View Graph of Matrix" menu selection allows the user to view a graph of the cost of each combination (plan) versus the output provided by each combination (plan) on their monitor. The "Print Graph of Matrix" menu selection allows the user to print the graph of the cost of each combination (plan) versus the output provided by each combination (plan).

The "Proceed with Analysis" menu selection will advance the program to the Computing Least Cost Combinations Screen.

Computing Least Cost Combinations Screen



The Computing Least Cost Combinations Screen will appear while the program is identifying and deleteing those combinations (plans) that provide the same level of output as another plans, but at a higher cost. This screen contains a box showing scrolling numbers to indicate that the computer is processing data. For some applications, the computer may complete this procedure so quickly that the user may not see this screen. When this process is completed, the Least Cost Combinations for Each Level of Output Menu will appear.



Least Cost Combinations for Each Level of Output Menu

Similar to the Combinations Sorted by Output and Cost Menu, the Least Cost Combinations for Each Level of Output Menu offers several options.

The “Print Matrix” menu selection allows the user to send a copy of all least-cost combinations of management measures (plans) for each level of output with their cost and output to the printer.

The “View Matrix” menu selection allows the user to scroll through the matrix of all least-cost combinations of management measures (plans) for every level of output with their cost and output on their monitor.

The “View Graph of Matrix” menu selection allows the user to view a graph of the cost of each least-cost combination (plan) for every level of output versus the output provided by each such plan.

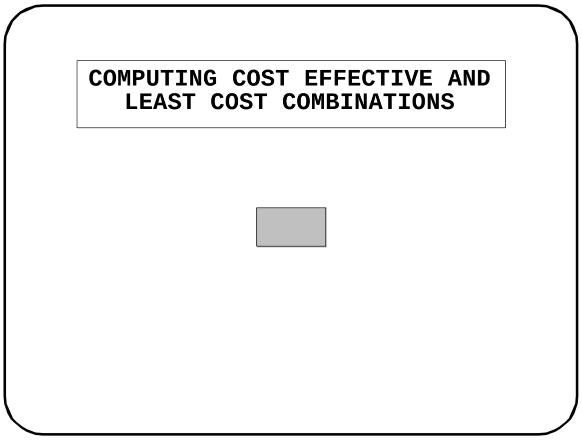
The “Print Graph of Matrix” menu selection allows the user to print the graph of the cost of each least-cost combination (plan) versus the output provided by each such plan.

The “Proceed with Analysis” menu selection will advance the program to the Computing Cost-Effective Least-Cost Combinations Screen.

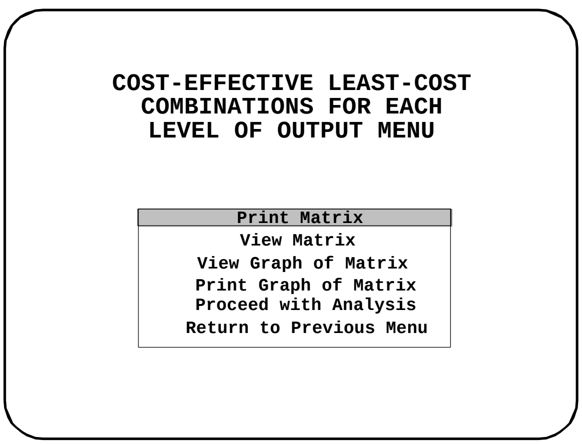
The “Return to Previous Menu Selection” will return the user to the Combinations Sorted by Output and Cost Menu.

Computing Cost Effective and Least Cost Combinations for Each Level of Output Screen

The Computing Cost Effective and Least Cost Combinations for Each Level of Output Screen appears while the program identifies and deletes all plans where a higher output level could be provided at less or equal cost by another plan. This procedure results in the identification of all cost effective plans.



The Computing Cost Effective and Least Cost Combinations Screen contains a box showing scrolling numbers to indicate that the computer is processing data. For some applications, the computer may complete this procedure so quickly that the user may not see this screen. As soon as the program has completed this process, the Cost Effective and Least Cost Combinations for Each Level of Output Menu will appear.



Cost Effective and Least Cost Combinations for Each Level of Output Menu

Similar to the Combinations Sorted by Output and Cost Menu and the Least Cost Combinations for Each Level of Output Menu, the Cost Effective and Least Cost Combinations for Each Level of Output Menu offers several options.

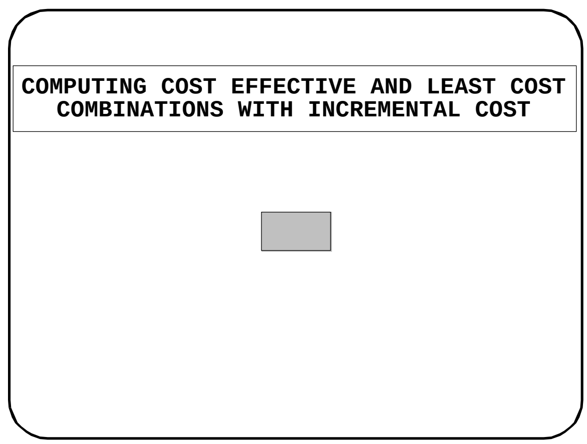
The "Print Matrix" menu selection allows the user to send a copy of all cost effective combinations of management measures (plans) with their cost and output to the printer.

The "View Matrix" menu selection allows the user to scroll through the matrix of all cost effective combinations of management measures (plans) with their cost and output on their monitor.

The "View Graph of Matrix" menu selection allows the user to view a graph of the cost of each cost effective combination (plan) versus the output provided by each such plan.

The "Print Graph of Matrix" menu selection allows the user to print the graph of the cost of each cost effective combination (plan) versus the output provided by each such plan.

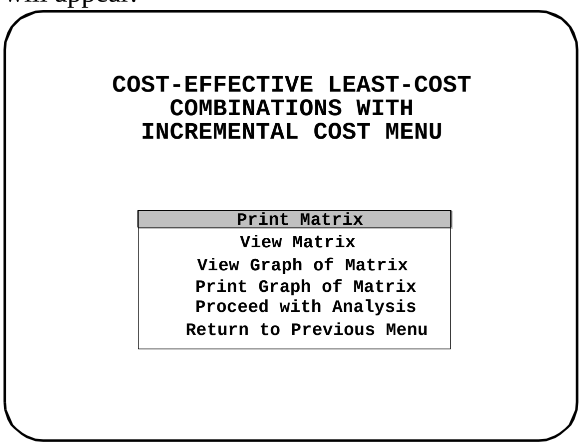
The "Proceed with Analysis" menu selection will advance the program to the Computing Cost-Effective Least-Cost Combinations with Incremental Cost Screen.



Computing Cost Effective and Least Cost Combinations with Incremental Cost Screen

The Computing Cost Effective and Least Cost Combinations with Incremental Cost Screen will appear while the program is calculating the incremental cost, incremental output and incremental cost per unit for advancing from each output level to the next. The procedure fills the previously empty data columns in our matrix.

This screen contains a box that shows scrolling numbers to indicate that the computer is processing data. For some applications, the computer may complete this procedure so quickly that the user may not see this screen. As soon as the program has completed this process, the Cost-Effective Least-Cost Combinations with Incremental Cost Menu will appear.



Cost-Effective Least-Cost Combinations with Incremental Cost Menu

Similar to the previous output menus, the Cost Effective and Least Cost Combinations with Incremental Cost Menu offers several options.

The "Print Matrix" menu selection allows the user to send a copy of all cost effective combinations of management measures (plans) with their cost and output, incremental cost and output, and incremental cost per unit to the printer.

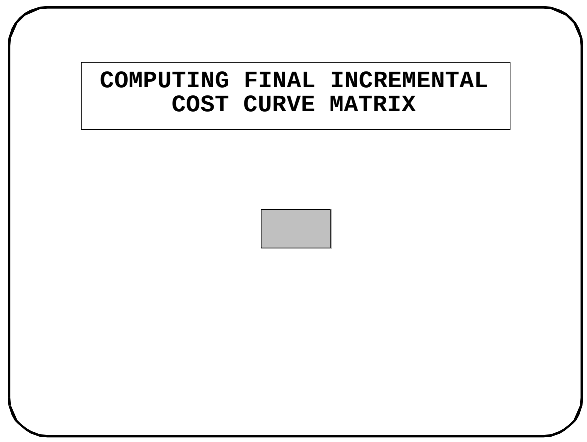
The "View Matrix" menu selection allows the user to scroll through the matrix of all cost effective combinations of management measures (plans) with their cost and output, incremental cost and output, and incremental cost per unit.

The "View Graph of Matrix" menu selection allows the user to view a graph of the incremental cost per unit of each cost effective combination (plan) versus the incremental output provided by each such plan.

The "Print Graph of Matrix" menu selection allows the user to print the graph of the incremental cost per unit of each cost effective combination (plan) versus the incremental output provided by each such plan.

The "Proceed with Analysis" menu selection will advance the program to the Computing Final Incremental Cost Curve Matrix Screen.

The "Return to Previous Menu" menu selection will return the user to the Cost-Effective and Least-Cost Combinations with Incremental Cost Menu.



Computing Final Incremental Cost Curve Matrix Screen

The Computing Final Incremental Cost Curve Matrix Screen will appear while the program identifies the combinations (plans) which comprise the "smooth" curve of plans with continuously increasing incremental costs per unit as described in Chapter Three.

This screen contains a box that shows scrolling numbers to indicate that the computer is processing data. For some applications, the computer may complete this procedure so quickly that the user may not see this screen. As soon as the program has completed this process, the Final Incremental Cost Display Menu will appear.

FINAL INCREMENTAL COST
DISPLAY MENU

Print Matrix
View Matrix
View Graph of Matrix
Print Graph of Matrix
Proceed with Analysis
Return to Previous Menu

Final Incremental Cost Display Menu

Similar to the previous output menus, the Final Incremental Cost Display Menu offers several options.

The "Print Matrix" menu selection allows the user to send a copy of the selected cost effective combinations of management measures (plans) that have increasing incremental cost per unit. This print copy will include the cost and output, incremental cost and output, and incremental cost per unit of each plan.

The "View Matrix" menu selection allows the user to scroll through the matrix of selected cost effective combinations of management measures (plans) that have increasing incremental cost per unit. This matrix will include the cost and output, incremental cost and output, and incremental cost per unit of each plan.

The "View Graph of Matrix" menu selection allows the user to view a graph of the incremental cost per unit of each selected cost effective combination (plan) versus the incremental output provided by each such combination (plan).

The "Print Graph of Matrix" menu selection allows the user to print the graph of the incremental cost per unit of each selected cost effective combination (plan) with increasing incremental cost per unit versus the incremental output provided by each such combination (plan).

The "Proceed with Analysis" menu selection will advance the program to the Report Management Menu.

REPORT MANAGEMENT
MENU

Print Matrix Menu
View Matrix Menu
View Graphs Menu
Print Graph Menu
Return to Previous Menu
Return to File Management Menu
Quit to Dos

The Report Management Menu

The Report Management Menu offers the following options: "Print Matrix Menu", "View Matrix Menu", "View Graphs Menu", "Print Graph Menu", "Return to Previous Menu", "Return to File Management Menu", and "Quit to DOS".

The "Print Matrix Menu" offers the opportunity to print any of the matrices created during the application. Similarly, the "View Graphs Menu" offers the opportunity to view any of the matrices created during the application.

The "Print Graphs Menu" offers the opportunity to print any of the graphs created during the application. Similarly, the "View Graphs Menu" offers the opportunity to view any of the graphs created during the application.

Selecting "Return to Previous Menu" will return the user to the Final Incremental Cost Display Menu.

Selecting "Return to File Management Menu" will return the user to the File Management Menu.

Selecting "Quit to DOS" will terminate the application, save all files and exit to DOS.

Upon selecting any of the "PRINT" or "VIEW" options from the Report Management Menu, the user will have the choice of viewing or printing the following matrices or their graphs: "Combinations Sorted by Output and Cost"; "Least-Cost Combinations for Each Level of Output"; "Cost-Effective Least-Cost Combinations"; "Cost-Effective Least-Cost Combinations with Incremental Cost"; and Final Incremental Cost". An example of a "Print" or "View" menu follows.

VIEW MATRICES
MENU

Combinations Sorted by Output and Cost
Least-Cost Combinations for Each Level of Output
Cost-Effective Combinations
Cost-Effective Combinations with Incremental Cost
Final Incremental Cost Curve
Return to Report Management Menu

Editing a File

When wishing to edit the input data in a previously created application, the user should select "Retrieve File" from the File Management Menu. After selecting a file to retrieve, the program will advance to the File Name Entry Screen with the file name appearing. Upon striking the enter key, the rest of the previously entered data appears. This data can be left as is, or edited. When finished with this screen, the program advances to the View or Edit Menu. If no editing is desired, select View Matrices to advance to the report management menu. If you wish to view or edit the scale and cost/output data for all measures, or to enter/delete/edit additional measures, select the Edit Matrices menu item.

Upon selecting Edit Matrices the program will start at the Management Measure Entry Screen and show only the first measure entered previously. Each time the enter key is struck, the next field of previously entered data will appear. All data can be edited/deleted. Additional data may be entered as well.

To edit a field, simply type over the data in the field. To pass over a field without editing data, simply hit the return key. It may be desirable to first make a copy of a file with a new name before editing input data. Editing the data without changing the name will cause the old file to be overwritten.